JUN 9 1916
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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.

VOL. CI.—No. 2632.] *LONDON: FRIDAY, JUNE 9, 1916.* [*Registered at the General Post Office as a Newspaper.*] [PRICE...6d. BY INLAND POST..8d.

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PATENTS AND DESIGNS ACT, 1907.

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Particulars of the proposed amendment were set forth in the *Illustrated Official Journal (Patents)*, issued on the 7th June, 1916.

Any person, or persons, may give notice of Opposition to the Amendment by leaving Patents Form No. 13, at the Patent Office, 25, Southampton Buildings, London, W.C., within one calendar month from the date of the said Journal.

W. TEMPLE FRANKS,
Comptroller-General.

JOHN E. RAWORTH, Queen Anne's Chambers, 28, Broadway, Westminster, S.W. Chartered Patent Agent. Agent for the Applicant. E 424

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Tenders, enclosed in sealed envelopes, addressed to the "Clerk, Metropolitan Water Board, Savoy Court, Strand, London, W.C." and endorsed "Tender for Lancashire Boilers," must be delivered at the Office of the Board not later than 10th July, 1916.

The Board do not bind themselves to accept the lowest or any Tender.

A. B. PILLING,
Clerk of the Board.

Savoy Court,
Strand, London, W.C.
6th June, 1916. E 410

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Bros. Patent RIPPING MACHINE, chuck suitable for gripping 5¼ in. external diameter; immediate delivery. — Address, E 425, Offices of ENGINEERING.

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Circular Water Jacketted BLAST FURNACE, complete with Electrically-driven Blower and all accessories.—For full particulars apply to, W. J. PERKINS, 26, Victoria St., Westminster, S.W. E 405

SOME ERRORS IN STEAM TABLES.

SOME very elaborate and convenient steam tables, issued of late years, have as their basis certain experimental work carried out in Germany. The compilers appear, however, to have adopted the results of these experiments without sufficient criticism of the methods employed, with the result that their tabulated values of total heats and specific volumes of steam are mutually inconsistent. When steam is expanded abiabatically the work done can, in fact, be estimated in two ways. It is equal to the area of the indicator diagram, which can be represented as $\frac{144}{J}\int V\,d\,p$, but is also equal to the difference between the total heats of the steam in its initial and final conditions. Hence, if H_0 denote the original total heat of the steam, and H_6 its final value, we should have, if the tables are correct, the equation

$$H_0 - H_6 = \frac{144}{J} \cdot \int V\,d\,p.$$

As a matter of fact, this relation, which is necessarily true, does not hold if the quantities involved be abstracted from tables based upon the experimental work already referred to.

For example, from one very elaborate and conveniently arranged table we deduce the following figures:—

p = 210.5 lb. per sq. in Entropy, 1.6822. Total heat, H_0 = 1333.8. Spec. vol. = 3.065 cub. ft. per lb.

If this steam be expanded isentropically down to 48.5 lb. per sq. in., we get

$$H_6 = 1189.55 \text{ B.Th.U., and } V_6 = 9.219.$$

Hence

$$H_0 - H_6 = 144.25 \text{ B.Th.U.}$$

The value of $\int V\,d\,p$ can be determined, without making any assumption as to the form of the expansion curve, by means of Weddle's rule. We have, in short:—

$$\int V\,d\,p = (p_0 - p_6)\,\overline{V},$$

where $\overline{V}$ denotes the mean value of V. Dividing the pressure range into six equal parts, we obtain from the tables in question the following values of V:—

No. ..	0.	1.	2.	3.	4.	5.	6.
p ..	210.5	183.5	156.5	129.5	102.4	75.5	48.5
V ..	3.065	3.392	3.815	4.397	5.236	6.603	9.219

By Weddle's rule

$$\overline{V} = \frac{1}{20}\,(V_0 + 5\,V_1 + V_2 + 6\,V_3 + V_4 + 5\,V_5 + V_6) = 4.8846.$$

In the tables in question the value of J is taken as 777.5 ft.-lb., so that we get:—

$$\frac{144}{J}\int V\,d\,p = \frac{144}{777.5} \cdot 162 + 4.8846 = 146.55 \text{ B.Th.U.},$$

which is 2.3 B.Th.U. more than the value derived from the total heats. In these days of close guarantees an error of over 1½ per cent. in the value of the available heat is by no means negligible, and the whole of the tables based upon the experimental work in question would seem to need revision.

In the foregoing the value of $\int V\,d\,p$ was determined without any assumption as to the form of the p V curve, by making use of Weddle's rule, and it may be suggested that the difference found is partly due to the use of this approximate formula of integration. For such cases as the foregoing, however, Weddle's rule is extremely accurate, as can be proved by comparing the results obtained by it and by the exact formula, when the expansion takes place according to the law $p\,V^{1.3} = \text{constant}$. For example, taking p_0 as 210 lb. per sq. in., V_0 as 3.4 cub. ft. per lb., and p_6 as 48 lb. per sq. in., then, from the assumed law of expansion, the values of V can be calculated to any desired degree of accuracy. The exact value of the integral is

$$\int V\,d\,p = \frac{1.3}{0.3}\,(P_0\,V_0 - P_6\,V_6).$$

Using five-figure logarithms, this rule gives

$$\int V\,d\,p = 893.10$$

whilst Weddle's rule gives the value 893.37. The error is therefore only about 1 part in 3000.

Since the errors in question are "errors in differences," the absolute values of the total heats tabulated are probably materially in error. There are, in fact, great difficulties in determining the values of the specific heats even of perfect gases. It will be remembered, for example, that the British Association Committee on Gaseous Explosions detected systematic errors in the Reichsanstalt values for the specific heats of air and other gases, and the determination of the specific heat of steam is still more difficult.

Attention was called to the existence of the discrepancy in question by an attempt to use the tables for reducing some experiments on a steam-turbine, in which initial and final temperatures and pressures had been very carefully observed.

The energy expended along the actual expansion-line is in such case given by the relation

$$U = \frac{144}{J} \cdot \frac{\lambda}{\lambda - 1}\,(p_0\,V_0 - p_1\,V_1),$$

where λ is equal to

$$\frac{\log p_0 - \log p_1}{\log V_0 - \log V_1}$$

and the useful work done is, or should be, equal to $H_0 - H_1$, where H denotes the total heat in 1 lb. of the steam.

The "hydraulic" efficiency therefore is

$$\eta = \frac{H_0 - H_1}{U}.$$

But it is easy to show that η is also equal to

$$\frac{\gamma}{\gamma - 1} \cdot \frac{\lambda - 1}{\lambda},$$

where γ denotes the index in the equation for adiabatic expansion—viz., $P.\,V^{\lambda} = C$.

The two values of η obtained on using the tables were most discordant, the relative efficiency of different experiments being in some cases reversed as one or the other expression was adopted for η. On the other hand, using Callendar's formulæ for the total heat and the specific volume of steam, consistent results were obtained. Other turbine results since investigated again show a greater consistency of the test figures when interpreted by the use of Callendar's formulæ instead of with the aid of these otherwise very convenient tables.

Callendar's values for the total heat and specific volume of superheated steam, which, as stated, are consistent *inter se*, are:—

$$V = 0.5948\,\frac{T}{p} - k.$$

Here T denotes the absolute temperature Fahr., and p the pressure in pounds per square inch, whilst k is a small correction, the values of which at different temperatures are as follow:—

Temp. Fahr. Deg.	k.	Temp. Fahr. Deg.	k.
122	0.665	437	0.141
167	0.495	482	0.121
212	0.405	527	0.101
257	0.312	572	0.085
302	0.261	617	0.072
347	0.206	662	0.060
392	0.175		

A curve plotted from these values makes it easy to read off the value of k for any intermediate temperature. At all ordinary pressures the value of k is practically independent of the pressure and varies with the temperature only.

Once the volume of the steam (superheated) is determined by this equation, the total heat in B.Th.U. can be calculated from the very simple relation, also due to Callendar:—

$$V = 1.2464\,\frac{(H - 835.2)}{p} - 0.0123.$$

According to Callendar, the equation for adiabatic expansion is

$$p\,V^{1.3} = \text{constant}.$$

This is in agreement with the value found by Makower—viz., 1.305, whilst the steam tables in question give a value of about 1.333. Since direct determinations of the index can be made with considerable accuracy, this difference again seems to indicate an error in the values tabulated.

THE MOUNT WILSON OBSERVATORY IN 1915.

THE issue of the Report of the Director of the Mount Wilson Observatory is a distinctive feature in the astronomical year; but interest in the document is by no means confined solely to astronomers. It expresses alike the achievements of the past and the hopes of the future. It describes the implements of attack, explores the ground that has been won, and indicates the direction in which further advance will be prosecuted. In the first few sentences we are reminded that the death grapple of European States has made itself felt in the remote mountains of California, and penetrated the small community devoted to peaceful science. Such untoward result need awaken no surprise, for the astronomers of all nations are welcomed under the Observatory's hospitable roof and all earnest students of science are kindly received. Dr. Kohlschutter forsook the quiet retreat with the view of joining the German Army, but was captured by an English vessel when on his way, and is now happily interned in England. Mr. R. S. Capon, of Oxford, also heard the call to arms, and with better luck is now serving his country at the Front.

Turning first of all to construction—a branch of the work of the observatory which appeals specially to engineers—we learn that the progress made with the 100-in. reflecting telescope has been continuous, and possibly, if we could grasp adequately all the various obstacles that have to be overcome in so huge an undertaking, rapid. The work of changing the spherical surface of the mirror to that of a paraboloid has occupied one year, and about 80 per cent. of the necessary work has been accomplished. That it is necessary to use a polishing tool of 850 sq. in. area is a sufficient proof of the severity of the labour involved. Concurrently with the figuring of the large mirror, the construction of a 60-in. plane mirror has been pursued and completed. This plane mirror will now be available for testing the 100-in. mirror, a difficult operation, which has hitherto been effected entirely at the centre of curvature, about 84 ft. from the surface of the glass. The new plane mirror has now been mounted so as to permit a motion of 66 in. in a line at right angles to the axes of the paraboloid, and by this means the optical testing will be possible both at the centre of curvature and at the focus, providing the necessary means for testing both the mirror as a whole and for detecting zonal errors in the general curvature. The 60-in. plane mirror in the course of working disclosed the necessity for a similar scrutiny. Originally and until just short of perfection, optical tests were made in the horizontal position of the plane, but in the more advanced stages the plane mirror was placed on edge in a vertical position and tested in combination with a 36-in. spherical mirror of 50 ft. radius of curvature, when, though the absence of any decided convexity or concavity of the plane mirror was manifest, the more delicate test revealed some fine narrow zones that demonstrated the need of special means for their detection and removal.

Meanwhile the heavy castings and mounting of the 100-in. reflector have been entrusted to a firm at Ford River, who appear to have met with great difficulties, and some delay has been experienced in forwarding the several pieces to Pasadena. Some of these weigh as much as 9 tons, and no small ingenuity has to be exercised in devising the means to convey such masses to the summit of Mount Wilson, nearly 6000 ft. high. Much experience has been gained by carrying up the materials for the dome, itself 100 ft. in diameter, of which the rails and girders were in some cases 24 ft. long, with a weight of more than 4 tons. These difficulties have, however, been safely overcome, and by this time the dome is probably complete, ensuring sufficient protection for the telescope mounting when it arrives The driving clock is completed, and after severe testing proved itself of excellent quality. Director Hale confidently expects that the mammoth reflector will be in working order by the end of this year.

After such examples of Gargantuan proportions it is of the nature of an anticlimax to speak of the

remodelling of the 60-ft. tower telescope and 30-ft. spectrograph, or the construction of a new 13-ft. spectroheliograph; but though such work might very well occupy the staff of an optical shop conducted on commercial lines, it by no means exhausts the activities that characterise the constructive work on Mount Wilson. There are further to be considered a machine for ruling optical gratings on an enlarged scale, additions to the Cassegrain and concave solar spectrographs, the grinding and mounting of a 10-in. portrait lens telescope; while in the Physical Department other work is going forward whose connection with astronomy is less apparent. A water-tank and apparatus for vortex experiments and the installation of a 20,000-volt power plant demonstrate how far astronomy has advanced from the traditional lines that popular notions attach to the duties of an observer. The determination of the places of the stars, the record of minute changes in their lustre, the position and motion of the solar system in the aggregate of the stellar universe, still afford ample scope for industrious and intelligent observation; but the problems pursued by Professor Hale, depending on number of ingenious hypotheses, demand for their solution the conduct of elaborate experiments which reproduce in the physical laboratory conditions and phenomena that approximate to those that obtain in the Sun, and where the forces under control may be made to provide evidence for or against suggested alternative explanations. For instance, the study of vortex motion offers the possibility of deciding between rival theories concerning the structure and origin of hydrogen flocculi connected with sun-spots. The simpler forms of these flocculi are described as unipolar, consisting of curved or radial lines surrounding single spots, and bipolar, those surrounding a bipolar group, resembling imperfectly the lines of force about a bar magnet. The explanation that some investigators offer of these latter depends on hydrodynamic phenomena, while others suggest falling hydrogen ions, which the magnetic fields in sun-spots would cause to assume paths resembling lines of force. Decisive evidence might be gained by watching the behaviour of a vortex mechanically formed. For this purpose a flexible wire helix, threaded with wooden discs to float most of the weight and increase friction, was made to spin at high velocity in a tank of water. "After some wandering, the lower extremity of the columnar vortex thus produced gradually turns up until it meets the surface, resulting in a semi-circular vortex ring, the two extremities of which are assumed by the hypotheses to represent the two spots of a bipolar group."

How far such experiments may be regarded as reproducing the actual conditions on the Sun, and consequently to what extent the conclusions are trustworthy, is open to question; but since Professor Hale proposes to pursue the inquiry on a larger scale, we shall certainly learn much about vortex motion, whatever connection such studies may have with hydrogen flocculi. Already the experiments have been arranged to show the motion of a secondary vortex produced in smoke-filled air from a primary just below the water surface. Photographs of such vortices exhibit an arched structure on one side of the axis of the group, and a more nearly radial structure on the opposite side, reproducing in its main features the typical structure observed in hydrogen flocculi. The vertical sections of these smoke vortices also exhibit the characteristic structure and motions of prominences flowing into sun-spots.

Such experiments explain the introduction of a tank into the equipment of an observatory: the large electric installation is required to investigate the intensity of the Sun's electric field; electric furnaces are needed for the mapping of metallic spectra at various high temperatures, and but for consideration of space it would be possible to show how each inquiry demands special apparatus for its due prosecution. A commanding feature in the conduct of the institution is the readiness with which the necessary instrumental means for the continuation of research is forthcoming. The energy needed to cope with the present, and to foresee and prepare for the future, excites both our surprise and admiration. Even while machinery skilfully devised and energetically employed is in use, the active brain of the Director is planning fresh and more powerful apparatus for the furtherance of a programme that embraces every department of astronomy. We have spoken only of the Sun, but without even faintly indicating the many inquiries into its physical constitution that are going on simultaneously, we may mention that one far-reaching series of observations has led to the suspicion that the time of rotation of the Sun on its axis is decreasing. In 1906 the observed equatorial velocity of rotation was 2.064 km. per sec., in 1908 2.053 km., and in 1915 1.949 km. These diminishing figures have obtained some support from other observatories, but it would at present be premature to draw any conclusion. We may be sure, however, that so interesting a question will be thoroughly sifted in future schemes of operation.

At night the stars and nebulæ engage the attention of the staff as actively as does the Sun in the daytime. We read in the report of nebulæ whose complicated structure cannot be revealed without photographic exposures varying from 9 to 12 hours. The spectrum of the nebula of Andromeda required an exposure of 34 hours! The examination of this spectrogram led to the interesting conclusion that there was no evidence of rotational displacement, but that the mean velocity of the nebula amounted to −329 km. per sec. Another nebula showed a velocity of +765 km. The meaning of these large velocities will be better appreciated if it is remembered that the average radial velocity of stars of large proper motion and known distance is only 24 km. per sec. The distances of the stars, the problem that eluded astronomical research for so long, are being determined in large numbers and with an accuracy that a few years ago was unattainable. Further, new methods of solving this fundamental problem are being evolved, for it is found that the absolute magnitude of stars, and consequently their distance, can be derived from the relative intensities of certain lines in their spectrum. By such means the number of known distances will be rapidly augmented, giving precision to our estimate of the scheme on which the stellar universe is framed. At the same time, further light is thrown on the process of evolution followed in individual stars, or in classes of stars, for the successive stages by which Novæ pass from a planetary nebula to that of a Wolf Rayet star have been observed in the case of the new star that appeared in Gemini in 1912. It has been followed through all the varying stages of its development till it has reached, apparently, permanent stability.

It has been possible in the present article to touch on only a few of the more salient features of last year's work at Mount Wilson. A measure of the activity that characterises all departments is shown by the summary of the results which are grouped into no less than 78 short paragraphs, each enunciating some fact that has been established, or indicating some research that has been pushed to a further stage. In both the amount of output and its originality, the work at Mount Wilson is unequalled either in Europe or America. The lesson to be drawn from this keen and many-sided activity is that research depends upon personal initiation and energy. The scientific organisation of the Germans, or the traditional methods of *laisser faire* pursued in this country, however priceless the material accumulated over a long interval of time may prove, can show nothing comparable in variety and extent to the results garnered in so short a period at Mount Wilson under the direction of Professor George E. Hale.

ON REDUCTION GEARS.

By JOHN H. MACALPINE.

(*Continued from page* 521.)

Recapitulation of the Foregoing Results.—I have shown:—

(*a*) That for each type of reduction gear there is one set of proportions that is better than any other.

(*b*) That each gear should be judged by the value of power constant it can safely carry, the best type of gear being that which allows of the highest power constant. Later I discuss at length what this constant implies.

(*c*) That a pinion with two bearings allows only of a low power constant.

(*d*) That the floating frame corrects from one-half to two-thirds of the effect of torsional yield of the pinion.

(*e*) That, especially in floating-frame gears, the handing of the helices may be such that the temperature error tends further to correct the torsional error.

(*f*) That far the greatest difficulty of rigid gears is their extreme sensitiveness to errors of alignment and that, within much wider limits of error than should occur in practice, the floating frame removes this difficulty entirely.

(*g*) That by properly designing the floating frame, misalignment of the pinion bearings due to one or more of these heating can be greatly diminished.

(*h*) That experience with gears appears conclusively to bear out our anticipation, founded on the foregoing considerations, that the introduction of the floating frame allows a large and safe rise of the power constant.

(*i*) That the 30 deg. helical angle which has been used satisfactorily with floating-frame gears gives considerable advantage over that of about 45 deg. usually adopted in rigid gears.

(*j*) That while there is a definite number of teeth which it is best for the pinion to have, experience has not yet shown clearly what that number is. My own belief is that it is not less than twenty-five and may be not less than thirty.

Marine Application of Reduction Gears.—There are very large and varied fields for the application of gears on land, to reduce the necessary high speed of an efficient turbine to that suitable for driving direct-current generators, pumps, rolling-mills, &c. But the most important single application, offering a field probably as large as all land applications combined, is to marine propulsion.

On shipboard there are three considerations of prime importance: efficiency, simplicity, and lightness.

1. *Efficiency.*—The high-speed geared turbine can be made more efficient than any other mode of propulsion: the turbine is highly economical, the gear absorbs almost no power, and the propeller may be run at maximum efficiency. From this follows diminished cost of operation.

2. *Simplicity.*—The reduction gear, even including its oiling system (pumps, &c.), has few parts and none which require manipulation in manœuvring the ship. Also, the increased speed of the geared turbine allows it to be greatly reduced in size and in rows and number of blades. This combination becomes, indeed, much less complex than the machinery for any other mode of propulsion except small internal-combustion engines using high-grade oil. The simpler the machinery the less liability is there to breakdown and to reduced efficiency.

3. *Lightness.*—The high efficiency leads to diminished weight per horse-power in the boiler-room. The gear and turbine are almost invariably lighter than the machinery for any other mode of propulsion and, in the large majority of cases, very much lighter. (Almost the only exceptions are the high-grade oil-engines fitted in small vessels and as auxiliary power in sailing-ships.) There will be a further saving of weight, as the increased efficiency will allow of a decrease in the weight of fuel for a given voyage. These three savings in weight may be utilised either to carry more dead weight on a given displacement, thus increasing earning power; or to diminish the displacement for a given tonnage carried and thus diminish the required horse-power and effect a further saving both in first coast and operating expense.

The saving of space might have been added to the above three advantages. This is usually very considerable. Under our present tonnage rules saving of space, in the case of most cargo-steamers, is not of value; but in large, fast liners and warships it is of the highest value.

Another prime requisite for warships is good efficiency at greatly reduced power. It also effects a valuable saving in all fast ships which, for various

reasons, will sometimes have to run at reduced speed. In the warship it gives large radius of action; in the fast liner it gives a better chance to reach port if the coal supply is short. I will show that the geared turbine notably fulfils this requirement.

Thus in all important respects the geared turbine is a great advance in marine practice. It was obvious what advantages would be gained in this wide field, and it was for this reason that we sought long and carefully for the best solution.

Let us discuss these advantages generally, without going into too much detail. The variation of conditions found in practice is almost infinite, and it would be wearisome and of little profit to try to make an approximate estimate of the advantage which could be at once used for any case that might arise. It is sufficient to show broadly that in almost all cases a valuable gain is made. Messrs. McLaren and Welsh carefully analyse twelve well-chosen and varied examples comprising high and low-speed ships of a wide range of tonnage and power. They generally find advantage, usually large advantage, from the change to geared turbines, and this notwithstanding that they are hampered by the low-power constant they had to adopt, keeping up the weight of their gears and leading to a lower ratio of reduction than they could otherwise have adopted without increasing the size of the large gear; their weights and steam consumption are also kept very high by the small peripheral speed of turbine to which the low-power constant tends to limit them. The mean peripheral velocity of blades at the low-pressure exhaust end, which they choose, is 300 ft. per second, whereas speeds of 600 ft. per second are now considered quite practical. This would have raised the percentage of increased economy and decreased weight and, where their figures are adverse to the geared turbine, the result would have been reversed.

Steam Consumption.—A 500-horse-power turbine running at 4000 to 5000 revolutions per minute can be constructed for a water rate of 12 lb. to 12.5 lb. per horse-power per hour with dry saturated steam and 28-in. vacuum. This speed would be applicable, with a single reduction, to fast ships and with double reduction to slow ships. The double reduction in the slow ship would give better economy, since it would allow of a higher speed of turbine, as we will see in the next example, and when treating of engine-room weights I will show considerable saving by adopting it.

In a ship of 10 knots speed and 2500 shaft horse-power the Westinghouse Machine Company guaranteed a water rate of 11.5 lb. per shaft horse-power per hour for a turbine of 3600 revolutions per minute, reduced by double reduction to 85 revolutions per minute of propeller. For single reduction from 1700 to 85 revolutions per minute they guaranteed 12 lb. These rates do not include the steam for the auxiliaries.

The lowest steam consumption of auxiliaries recorded, of which I am aware, is that for the Saxonia in the trials carried out by the Boiler Committee of the British Admiralty.* They give 0.86 lb. per hour per indicated horse-power of the main engines at 9099 indicated horse-power, or practically full power, as the cut-off in the high-pressure cylinder must have been about 0.7 to give the mean pressure attained. This included steam to the forced-draught fans. It is probably a low result. The rates recorded in the same table for H.M.S. Hyacinth and Minerva vary considerably with the power and other conditions, but may be taken roughly about twice that for the Saxonia. Probably we will not be understating the value, which can readily be realised by taking 1.25 lb. for a large engine and 2 lb. for one of 500 horse-power.

Adding this latter value to both the above cases gives the total water rates:—

	Lb. per S.H.P. per Hour.
500 horse-power single-reduction ...	14.5
500 ,, double ,, ...	14.0
2500 ,, single ,, ...	14.0
2500 ,, double ,, ...	13.5

For large powers higher economy can be attained.

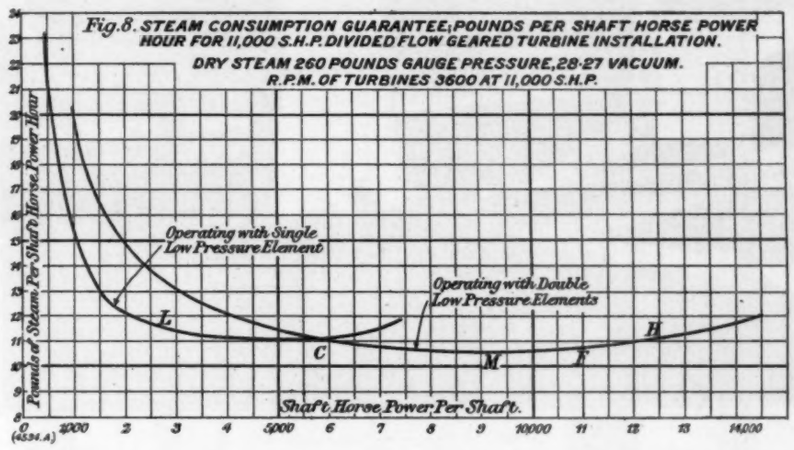
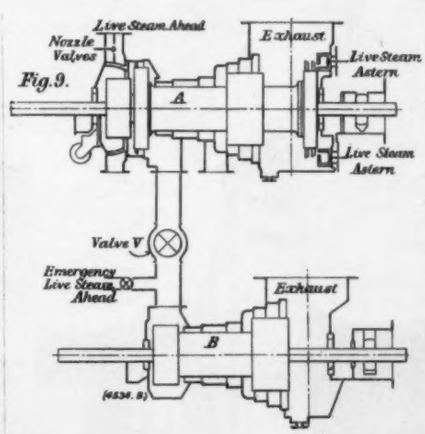


Fig. 8. STEAM CONSUMPTION GUARANTEE; POUNDS PER SHAFT HORSE POWER HOUR FOR 11,000 S.H.P. DIVIDED FLOW GEARED TURBINE INSTALLATION.
DRY STEAM 260 POUNDS GAUGE PRESSURE, 28·27 VACUUM.
R.P.M. OF TURBINES 3600 AT 11,000 S.H.P.
Pounds of Steam Per Shaft Horse Power Hour
Operating with Single Low Pressure Element
Operating with Double Low Pressure Elements
L
C
M
F
H
Shaft Horse Power Per Shaft.
(4534. A)



In Fig. 8 I give the consumption guarantees by the Westinghouse Machine Company for 11,000-horse-power cross-compound turbines. The water rates at the various powers have been carefully computed and it is confidently expected that the actual performance will improve sensibly on the guarantee. At maximum efficiency the consumption is 10.65 lb. per shaft horse-power per hour, and at full power 10.8 lb. per shaft horse-power per hour. Adding 1.25 lb. for auxiliary steam we have a total consumption of, say, 12 lb. per shaft horse-power per hour.

Thus, from small to large geared turbines we have a full-power water rate, including auxiliaries, ranging from 14.5 lb. to 12 lb. per shaft horse-power per hour. These figures are conservative, as better results have been realised.

* See ENGINEERING, vol. lxxiii., page 329.

The total increase of efficiency for each ship at full power will be sufficiently indicated by the percentage decrease in boiler weight which it follows more or less closely. This will shortly be treated under *Boiler-Room Weights.*

Messrs. McLaren and Welsh, by using a low peripheral speed, do not reach, even at full power, the revolutions per minute which would give maximum turbine efficiency, and, consequently, as the speed is reduced their economy rapidly falls off. Indeed, in this respect they attain a result little better than that of the direct-connected turbine, which, to accommodate the requirements of the propeller as far as possible, is always under-speeded. The efficiency at low powers can be greatly enhanced by adopting cruising turbines, as is very frequently done in warships fitted with direct-connected turbines. These are connected through gears and a clutch to the main turbine shaft, so that they can be operated at comparatively high speed when the ship is cruising.

But it was pointed out in connection with the description of the experimental gear* that, with the geared turbine, economy could be effected at low speed by so designing the turbine that the speed for maximum efficiency would be reached at less than full speed. This is realised in Fig. 8 which shows remarkably good economy down to about one-fifth of full power, rivalling the reciprocating engine in this respect. It enhances the value of this advance that it is gained by a simplification of the machinery.

Divided-Flow Turbine.—Before discussing the weights of machinery I will make a digression to describe briefly the "divided-flow turbine" brought forward by the Westinghouse Machine Company. It is the predicted performance of this turbine which Fig. 8 represents, and I believe it will be found to be an interesting advance in marine-turbine design.

The turbine in one form is shown in outline in Fig. 9. In the upper part of the figure is a combination high-pressure (impulse) low-pressure (reaction) and astern turbine A; and in the lower part a low-pressure (reaction) turbine B. Both of these actuate one large gear through separate pinions, none of which gearing is shown in the diagram. Steam is admitted through expanding nozzles, impinging on a two-row impulse element. These nozzles are arranged in groups which can be closed one by one to reduce the power, thus retaining full inlet pressure at all powers. At or near full power the steam, after passing the nozzles, divides and flows in approximately equal streams through the two low-pressure elements composed of reaction blading. After passing these it flows to the condenser. The steam consumption under these high-power conditions is shown by curve H, Fig. 8. The design is such that the point M of maximum efficiency occurs at less than full power F, giving almost equal efficiency over a long range from F to C. The relative position of M and F can, of course, be changed by a change in the design. When the power has been reduced, in this case to about one-half, a cross-connection valve V in the pipe between the combination element A and the low-pressure element B, is closed and all the power is then developed in A. Rotor B then revolves idly in the vacuum of the condenser, or on long cruises may be disconnected. Thus at cruising speed only part of the machinery is in operation, while, where cruising turbines are fitted, more is operated than at full power. The steam consumption at low powers is given by curve L, Fig. 8. The added economy shown by this curve arises from three separate sources:—

1. To gain the highest economy from the impulse element the back pressure, after the steam has passed through these blades, should actually increase as the power falls, since, in a marine application, the speed also falls. Shutting off element B causes this pressure to be considerably higher than when valve V is open, thus more nearly realising the best condition, and the back pressure only falls very low at greatly reduced powers.

2. The opening through the reaction blading is approximately halved, and is thus better propor-

* See ENGINEERING, vol. lxxxviii., page 379, and Fig. 10.

LIFT-LOCKS AT PETERBOROUGH, ON THE TRENT CANAL, ONTARIO, CANADA.

DESIGNED AND CONSTRUCTED BY THE DOMINION BRIDGE COMPANY, LIMITED, ENGINEERS, MONTREAL, CANADA.

(*For Description, see opposite Page.*)

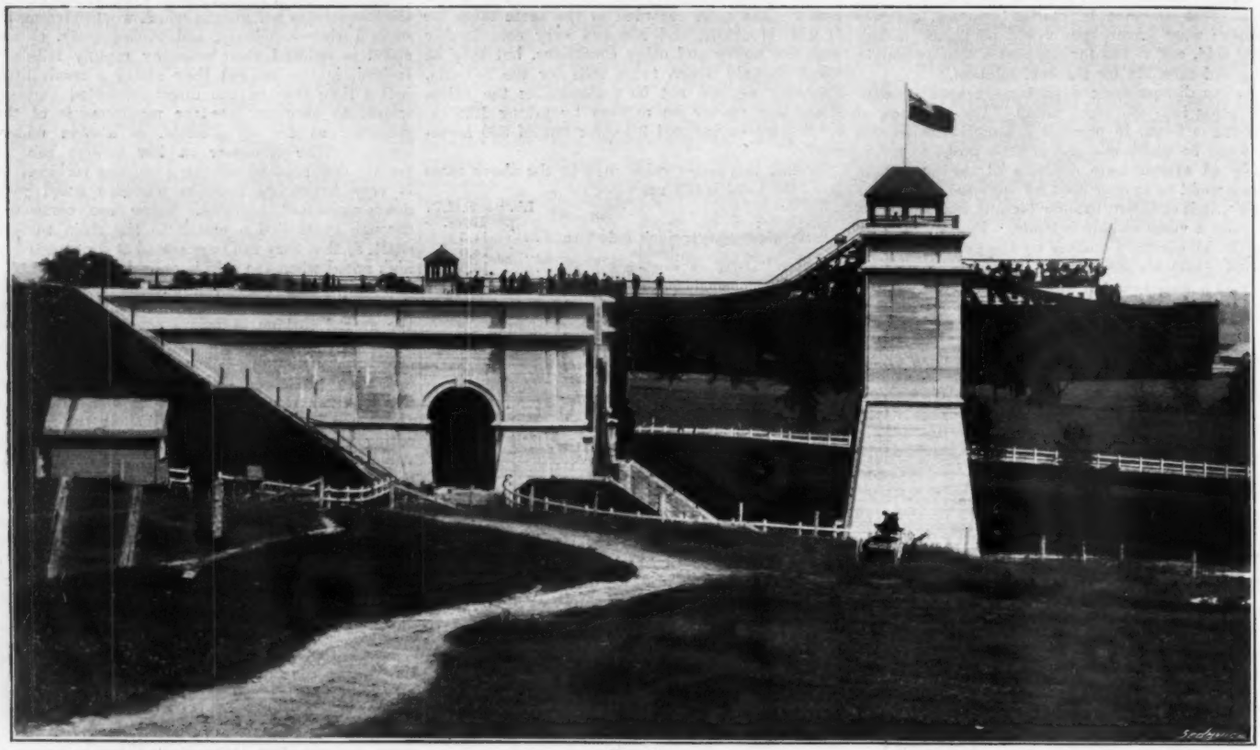


FIG. 1.

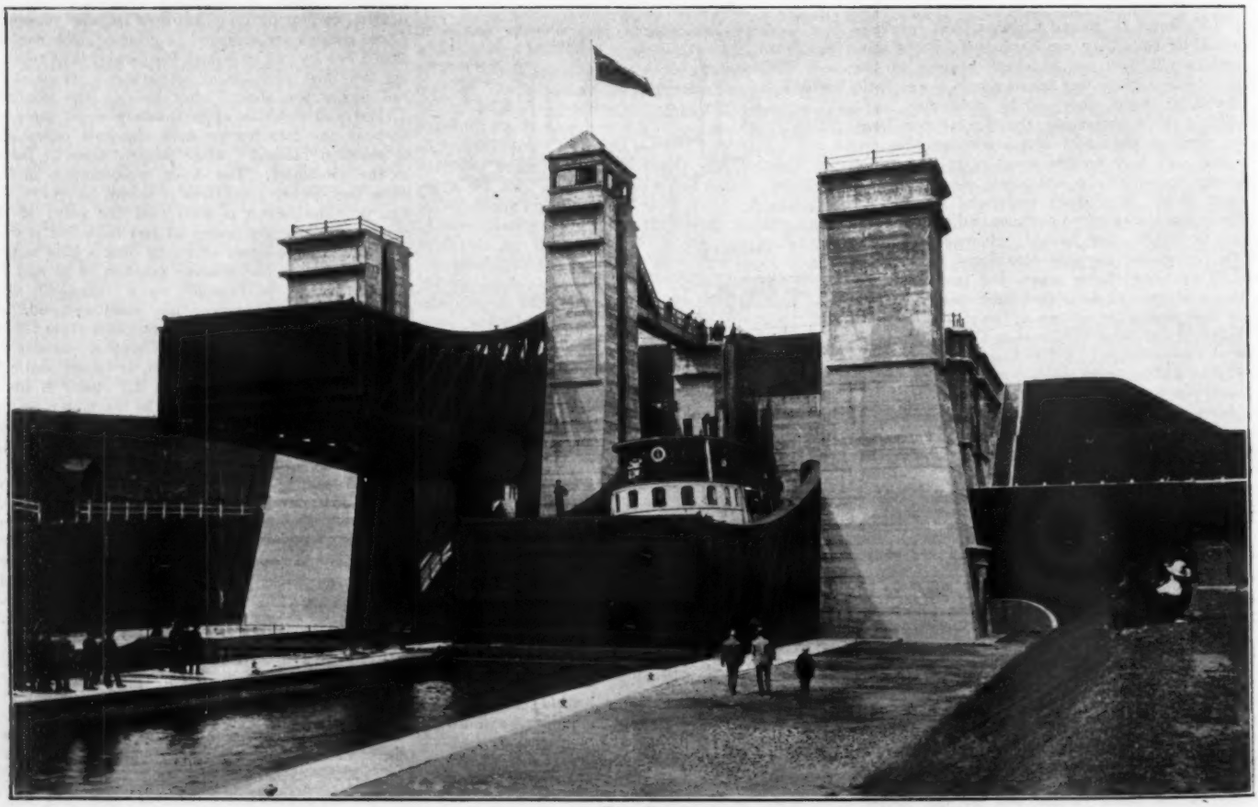
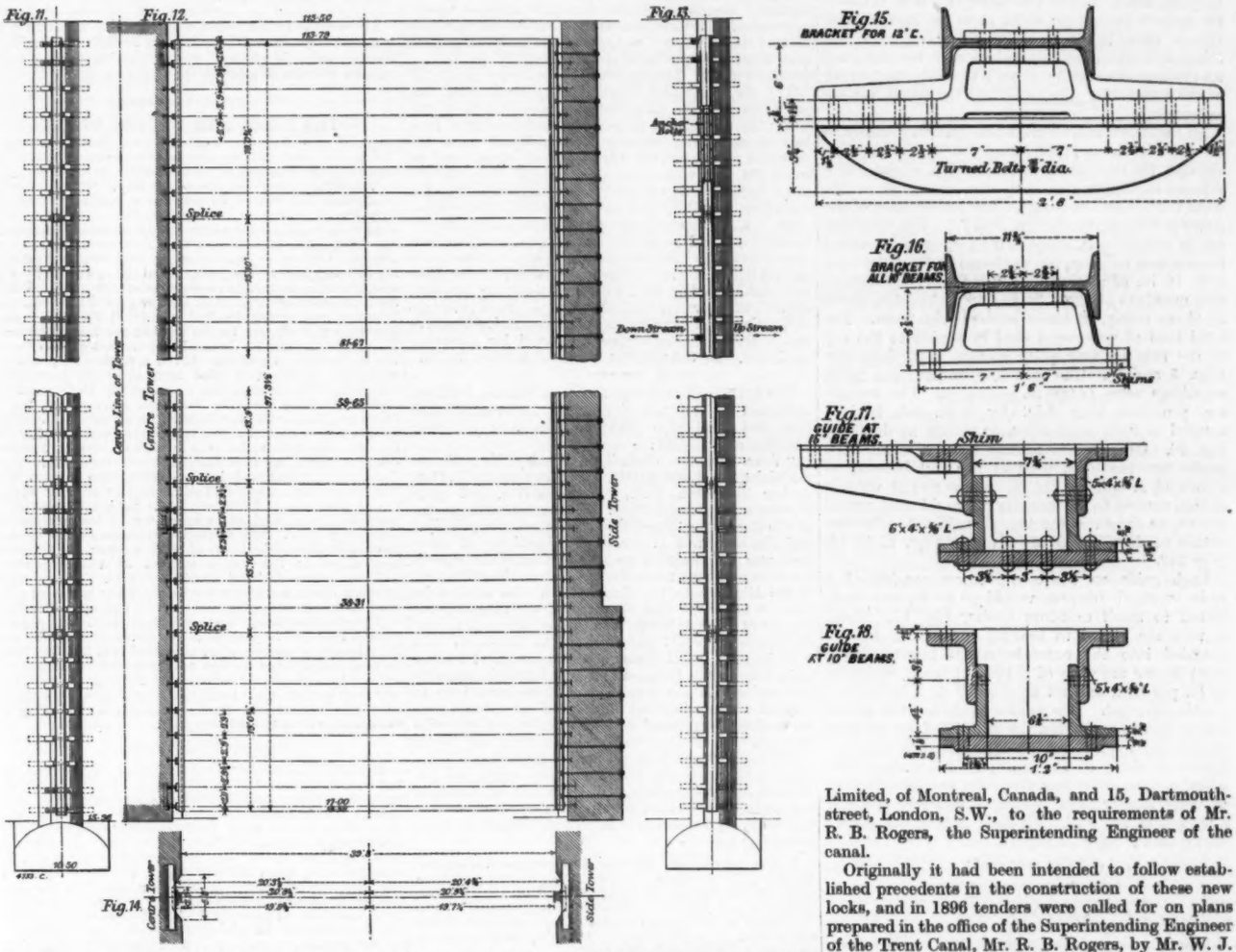


FIG. 2.

LIFT-LOCKS AT PETERBOROUGH, ON THE TRENT CANAL, ONTARIO, CANADA.

DESIGNED AND CONSTRUCTED BY THE DOMINION BRIDGE COMPANY, LIMITED, ENGINEERS, MONTREAL, CANADA.



tioned to the reduced steam flow. The efficiency of this part of the blading is therefore kept up.

3. The impulse blade speed is designed for the larger pressure drop existing during cruising. While this makes the pressure drop too small at full power, the slight loss of efficiency is compensated, at least in part, by diminished friction of the impulse wheel, there being only one impulse wheel for the two reaction elements.

There are other advantages:—

(*a*) The ratio of length of blade to diameter of drum remaining the same, the radial length of the reaction blades in the divided elements will be smaller than if there were only one element. Consequently the dimensions of their cross-section will be reduced and, while their number will be increased, their weight and the length of the drums in which they are set will be so reduced that the total weight of turbine will be much diminished.

(*b*) If element B is disabled, element A can be operated alone. Also, if element A is disabled, the emergency live-steam valve shown will allow element B to be used. A considerable fraction of full speed could then be developed with an increase of only about 10 per cent. in the water rate. Or if the reaction blading of element A were seriously disabled, so that it would offer little resistance to steam passing to the condenser, the two pinions could still be used and nearly full speed attained by shutting valve V and admitting live steam separately to the impulse blades and to element B.

(*c*) Both elements A and B are connected to the condenser all the time. In all turbine arrangements where high-pressure turbines, and often intermediate turbines, are fitted with direct connections to the condenser, a large and heavy exhaust-valve must be fitted to each of these connections. Hence in the divided-flow turbine a considerable complication and extra weight and space are saved.

(*d*) The high rotative speed of the geared turbine permits of the employment of a single two-row impulse element for the astern turbine, thus diminishing heating of the exhaust steam and loss of power by friction. Experiments at the Westinghouse Machine Company show that this will develop fully 60 per cent. of the full ahead power on the same steam flow, which is ample. If desired, a second astern turbine could be placed in element B, but that seems quite uncalled for in ships with two or more shafts.

(*To be continued.*)

LIFT-LOCKS ON THE TRENT CANAL, CANADA.

By means of the Trent Canal a waterway is provided through Ontario from Georgian Bay, Lake Huron, to Quinte Bay on Lake Ontario. In this way communication is established by water between the lakes above the Niagara Falls and the St. Lawrence River. To meet the needs of the increasing traffic two large lift-locks have been established on this canal, one being situated at Peterborough and the other at Kirkfield. These locks, the general character of which is well shown in Figs. 1 and 2, page 548, have been designed and constructed by the Dominion Bridge Company, Limited, of Montreal, Canada, and 15, Dartmouth-street, London, S.W., to the requirements of Mr. R. B. Rogers, the Superintending Engineer of the canal.

Originally it had been intended to follow established precedents in the construction of these new locks, and in 1896 tenders were called for on plans prepared in the office of the Superintending Engineer of the Trent Canal, Mr. R. B. Rogers, by Mr. W. J. Francis, M. Inst. C.E. These plans followed the general scheme and details of the La Louviere Lock in Belgium, Les Fontinettes Lock in France, and the Darlington Lock in England, of which latter work Messrs. Stansfield were the engineers. These plans called for presses built of narrow rabbetted rolled-steel rings shrunk on cast-iron sections, which were afterwards to be lined with copper. The chambers were to be supported by plate girders, the webs of which were intended as side plates for the trough; and the gates for chambers and reaches were to be of the vertical lift type. The engineers of the Dominion Bridge Company, Limited, however, submitted alternative designs, and it is to these that the locks were ultimately built. This alternative lay-out differed from the original scheme in the following special features. The presses were to be built up of circular flanged sections of cast steel, the chambers were to be supported by openwork latticed trusses, which are well shown in Figs. 1 and 2, already referred to, and the chamber and reach-gates were to be made to hinge downwards, with certain novel features in the method of handling them and of sealing the joints between gate and chamber and between chamber and reach.

Each lift consists of a pair of large water-chambers, each capable of receiving a vessel and each supported by a large ram. These rams work in large hydraulic presses or cylinders, so connected that the descent of one chamber automatically forces up the other. Under ordinary conditions the upper chamber is held in position at a point 6 in. or 8 in. below the limit of the stroke. It

thus contains 6 in. or 8 in. of water surcharge, which is quite sufficient, when the by-pass is open, to overcome the friction and impart the necessary acceleration to the system. On this by-pass, which allows the water to flow between the presses during operation, there are three valves. One of these is the main control valve, while the other two are auxiliary valves and are designed to close automatically should there be any break in the connecting pipe or should the speed become excessive.

In Fig. 3, Plate XLVII., which refers especially to the installation at Peterborough, we give a key plan, showing the two chambers side by side, whilst Fig. 4 represents diagrammatically the character of the truss supporting the trough. The construction of the latter is fully shown in Figs. 5 to 10. The chambers are, it will be seen, supported by openwork latticed trusses and measure 134 ft. long, 33 ft. wide, with 9 ft. 10 in. of plating on the sides. The diagonal web members of these trusses are flat plates, owing to there being no stress reversals in them. The total load of water and steel is carried to the top of the ram by four plate girders, 9 ft. deep (see Figs. 5 and 9). The unit stresses used for fixing scantlings were 12,000 lb. per sq. in. The troughs are provided with 2-in. by 12-in. oak fenders, secured to their inner sides, as shown in detail by Fig. 10. Outside the central strut of each truss guides are provided, both at top and bottom, as shown at A and B, Fig. 9. These run in vertical guides, secured to the masonry of the side and central towers, as shown in the key plan, Fig. 3. Further details of these guides are given in Figs. 11 to 18, page 549.

Each guide on the centre tower consists of a 12-in. vertical I-beam, weighing 40 lb. per foot, bolted to small cast-iron chairs, Fig. 17. These in turn are bolted to bearing and anchor beams, moulded into the concrete centre tower. These short beams are each of a 10-in. I-beam, weighing 25 lb. per foot, and set at about 2 ft. 8 in. centres (on the average). The guides on the outside towers are of box shape, Figs. 15 and 16, fabricated of plates and angles and anchored to the concrete towers similarly to the centre guides, except that additional security was given by the introduction of long anchor-bolts passing completely through a section of the wall. All these details are clearly shown on the right of Fig. 12.

(To be continued.)

INDUSTRIAL NOTES.

A PRONOUNCEMENT was given last week by Sheriff Fyfe at a local munitions tribunal, held in the County Buildings, Glasgow, in connection with an application by an apprentice boilermaker for a clearance certificate. The application was opposed by the employers on the ground that the apprenticeship term had not expired, it being alleged that, according to local practice, it did not begin when the lad entered the works, but six months later, when he had started on boilermaker's work proper. The Sheriff intimated that the tribunal had decided to ask the employers to grant the certificate. The cause of the present unrest among apprentices was, he stated, not far to seek. It was the same as the cause of unrest among other classes—*i.e.*, the lure of higher earnings which now ruled. When capable youths were so much in demand, and when working even as common labourers they could earn two or three times an apprentice's wage, it was not suprising that they should chafe under their apprenticeship restrictions. If they would, however, reflect a little, he thought they would see that it was not in their own best interest to abandon their apprenticeship to benefit temporarily by the present artificial conditions, which might be short-lived; they would be sacrificing their future career for the present, fleeting advantage of getting more money.

But apart from national and personal considerations, apprentices appeared to forget that they were not free agents; they were under contract, and the Munitions Act did not countenance breach of contract. When a youth entered an establishment with the avowed intention of serving the term of apprenticeship recognised in any particular trade, and the employer received him for that purpose, he became an apprentice quite as fully as if he had been engaged under a written indenture. It seemed obvious, therefore, that for a munitions tribunal to grant a leaving certificate to an apprentice whose time had not expired would be to permit him to use the machinery of the Act to evade the fulfilment of his apprenticeship contract. This would be an abuse of the Munitions Act which the tribunal could not countenance, and he, Sheriff Fyfe, had often asked apprentices whether they were seeking to transfer their apprenticeship, but had never yet obtained from them an answer in the affirmative. The Statutes did not contemplate that until his apprenticeship period had expired a leaving certificate should be granted to any apprentice. But there were various considerations which affected the duration of an apprenticeship; in the present case there was an alleged postponement of the date of commencement. The applicant commenced on March 23, 1911; the recognised apprenticeship term being five years, his apprenticeship ostensibly expired on March 23, 1916; the applicant was ostensibly now entitled to a leaving certificate, because the employers were not prepared to give him the "full standard wage," and he could get that wage elsewhere. Sheriff Fyfe did not think there was any room for the suggestion that the employers were trying to get six months' journeyman work for an apprentice's wage. Nor was there any question of bad time-keeping. It was a quite clean question of principle, and the employers' representative and the Boilermakers' Society's representative were there in a quite friendly way, desiring to get the question settled whether the existence of a trade practice postponing the commencement of an apprenticeship term was a relevant plea against a demand for a leaving certificate. He thought that it was not a relevant plea.

The following letter, says the Press Bureau, has been addressed by the Executive of the Boilermakers and Iron and Steel Ship Builders' Society to all their branches and officials:—

"Your Executive Council, on Monday, May 29, met the Minister of Munitions (Mr. Lloyd George), the Rt. Hon. Arthur Henderson, M.P., Dr. Macnamara, and other Government representatives. There were also present at the Conference representatives of all the principal societies concerned in our allied industries. A statement was made showing the absolute immediate urgency for ships and munitions of war. From the statements of the Ministers to the Conference it was made quite clear to all of us that the lives of our men and the success of our whole efforts in this war depended upon the efforts we could put forth in the shipyards and workshops. The Ministers of the Government made a plain statement of facts, and intimated that the question was entirely in our hands; and if we decided not to respond to the appeal no effort would be made to press the workmen concerned to defer holidays, or otherwise maintain the output. So impressed were the trade-union representatives at the conference with the statement of the case, the urgent military needs, and the decision of the Government to leave it in the hands of the workmen concerned to ensure safety at least, that the following resolution was passed without a single dissenting vote:—

It was unanimously resolved to recommend that the Whitsuntide Holidays be postponed for two months—until the end of July. In the meantime local conferences are to be held with the trade-union workmen concerned. The delay in holidays to be decided by the men themselves, and all work done on customary holidays to be paid for at the extra district rates.

The Executive Council would therefore recommend the resolution to the loyalty of our members, and ask each and all of them to do everything in their power in the national cause. There solution asks that any regular holidays falling between this date and July 31 be deferred to a date in August; every workman to be then entitled to the full number of deferred holidays. Any time worked on usual holidays to be paid for at the usual holiday rates in terms of the agreements or customs of each district."

With further reference to our note on page 525 *ante*, on the subject of the South Wales coal-miners' difficulty, representatives of the South Wales Coalowners' Association met in London on Thursday, the 1st inst., with a view to hear Sir George Askwith's proposals following upon his consultation with the South Wales miners' leaders. These proposals contained the suggestion that the miners' claim for a 15 per cent. advance in wages should be granted by the coalowners. The latter met again, in Cardiff, on Monday last, when they discussed the Government's suggestion. They passed a strong resolution of protest against the action taken by the Government in directing that an advance should be made without an inquiry being held in accordance with the terms of the Conciliation Board's agreement to determine whether the men were entitled to it. In view, however, of the national crisis, they decided to recommend the members of their Association to pay the advance in question, pending a special meeting which would be called to decide upon what further action they would take in the matter.

The Committee on Production met last Tuesday at Old Palace Yard as a Court of Arbitration, and heard an application for an advance in wages to the skilled craftsmen in the engineering shops of the North British, Caledonian, and Glasgow and South-Western Railways when the representatives of the companies announced that they were prepared to grant 1s. advance per week to time workers and 2½ per cent. to piece workers. The offer was acccepted by the men's representatives.

The dispute in the cotton trade remains unsettled; a number of operatives have handed in their notices, but the impression is current and is gaining ground that matters will not be allowed to reach a crisis.

NOTES FROM THE UNITED STATES.

PHILADELPHIA, May 24, 1916.

FURNACE and mill production continues at the very highest limit of capacity. Additional capacity is coming in steadily and much more is on the way. This increased production has served to prevent a runaway market. Open-hearth billets and sheet bars have been actually shaded in price in consequence of this increased capacity. The European demand for munition material is very urgent. Orders for shell steel are now pending calling for delivery late in the year, but these orders have not been placed; very rigid inspection is maintained, resulting in considerable quantities of rejected steel; the manufacturers are trying to find a market for this steel. France and Italy are in the market for large supplies. The general domestic demand is somewhat quieter, and the impression is growing that a recession in prices is probable. Plates and steel bars show an increasing demand. The shipbuilders are pressing their requirements for plate and the Japanese Government have failed to place orders for 12,000 tons of wire rods. The Italian Government has finally closed an order for 32,000 tons of steel bars to be used in shell-making at 5 cents per lb., taken by the Carbon Steel Company. The Pennsylvania Railroad has re-entered the market for 100 locomotives, of which 75 will be of the "Mikado" type, for its lines east of Pittsburg. The Lehigh Valley Company has re-entered the market for 75 locomotives of the heavy type. The Canadian Government is in the market for 2000 freight cars of various types, the Havana Central wants 750 freight cars of 30 tons capacity, and the Cuban Railroad desires 400 cars. The greatest pressure exists for plates for shipbuilding purposes and general construction in which plate enters. All other mill products continue in excellent demand. It appears though that it is impossible to record much new business for a long time to come, but nevertheless it is a fact that there are enormous foreign and domestic requirements yet to be covered. The renewed rumours of possible war termination find little credence here among those who have no interest, direct or indirect, in the selling of munition or food or other supplies.

THE SPITZBERGEN COAL DEPOSITS.—At the end of last month coal-mining in Spitzbergen was expected to begin in earnest, as the ports were thus free from ice, and regular steamer traffic to Norway could be established. In addition to the large Norwegian Spitzbergen mining syndicate, a Bergen syndicate has bought coal deposits in Spitzbergen for a very substantial sum, and it is expected that some 500 to 600 men will be working at the Spitzbergen coal-mines this summer. The Swedes, too, are apparently about to take up rational coal-mining in Spitzbergen, and Russia is also expected to start work this year in the mines, of which an expedition, despatched by the Russian Government, took possession some time ago.

THE SURVEYORS' INSTITUTION—MILITARY SERVICE.—The large number of men possessing surveying and constructional qualifications who are now being called up for military service, makes it impracticable for the authorities in all cases to take advantage of their professional experience by allocating them to the technical branches of the Army. It may therefore be of interest to some to hear that the Secretary of the Institution is in a position to say that Lieut.-Col. Cranfield, commanding the 37th D.C.O. (Middlesex Regiment), is prepared to give members of the Institution or their assistants an opportunity of enlisting in that battalion, and, as far as possible, to allow them to serve together in the same platoon. Intending recruits should communicate direct to the headquarters of the battalion at Solefields Camp, Sevenoaks.

THE BRITISH ASSOCIATION.—As in 1915, the British Association will assemble for a short, strictly scientific meeting this year, deprived of entertainments and excursions. The meeting is to open at Newcastle-upon-Tyne on Tuesday, September 5, and to disperse on the Saturday of the week, September 9. The President-elect is Sir Arthur Evans, F.R.S., Pres. S.A., an archæologist. Mr. G. G. Stoney, F.R.S., will preside over the Engineering Section, G, and Professor G. W. O. Howe will be the recorder of that section; his address is 22, Dorset-road, Merton Park, Surrey. The corresponding officers of Section A will be Professor A. N. Whitehead, F.R.S., and Professor A. S. Eddington, F.R.S. (of the Cambridge Observatory), and of Section B, Professor G. G. Henderson and Dr. A. Holt (of Dowsfield, Allerton, Liverpool). Some of the works of the Tyneside will be thrown open to members, it is hoped. There has been great industrial development, of course, since 1889, when the Association last visited Newcastle. The honorary local secretaries are Professor Phillips Bedson, D.Sc., and Mr. E. W. Fraser Smith, whose offices are at Bolbec Hall, Newcastle. The invitation circulars have just been sent to old members from the London offices of the Association at Burlington House, Piccadilly, W.

MANCHESTER STEAM-USERS' ASSOCIATION.

THE annual meeting of the members of this Association was held on Tuesday, May 30, at the offices, 9, Mount-street, Manchester, the President, Mr. Adam Dugdale, of Blackburn, in the chair.

The report of the Committee of Management was read by the Secretary. It stated that at the close of 1915 the number of boilers enrolled and the revenue for the year were the highest ever attained, thus constituting a record in the association's history. The total number of boilers under inspection on December 31 was 10,793, showing an increase of 401 over the previous year. The revenue amounted to 22,641*l.* 16s. 6d., being an increase of 1382*l.* 15s. 5d., and the net surplus in favour of the year was 2109*l.* 11s. 3d. Railway and British War Stock had been purchased during the year, and the total of the reserve fund now stands at 50,325*l.*

The report went on to say that in the matter of boiler inspections the past year was the busiest the Association had ever experienced, and it was difficult to meet all the demands made upon the inspectors. In addition to the ordinary thorough examinations required of the boilers of the members, a very large number of new and also of second-hand boilers were examined on behalf of His Majesty's Government and of industrial firms mainly connected with the manufacture of munitions of war in various parts of the country. The gross total of examinations made in 1915 was 22,297. Of these, as many as 10,645 were "internal," "flue" and "entire" examinations, the highest number hitherto reached in one year.

Many of the boilers and vessels for steam pressure, examined as to their fitness for purchase, were found unfit and were rejected, while others had to undergo structural alterations or repairs to make them suitable, thus illustrating the value of timely inspection.

The Committee had to report that a tube in a water-tube boiler at work drew out of its hole in the upper drum, due to overheating. Unfortunately one of the attendants in his excitement climbed up a ladder into the cloud of steam, where he was seriously scalded, and died a few days later. A second man, who was in the stokehold at the time, left it by the proper exit and got out uninjured. The overheating was due to scale in the tube, which had not been cleaned as often as necessary. This was owing to the pressure of work due to the war. After 61 years of remarkable immunity the Committee regretted that the first fatality had occurred in connection with a boiler having the Association's guarantee, but no discredit or blame attached to the Association in connection with the accident.

Outside its ranks the Association had noted throughout the United Kingdom during the year the occurrence of 48 explosions, killing 22 persons and injuring 54 others. Of these, 19, killing 12 persons and injuring 21 others, may be termed "boiler explosions proper," while the remaining 29, killing 10 persons and injuring 33 others, may be termed "miscellaneous" explosions—*i.e.*, those arising from steam-pipes, stop-valves. kiers, stills, drying-cylinders, bakers' ovens, &c.

Eleven of the Association's staff (not boiler inspectors) had joined the Colours, and the Committee regretted to state that one had been killed in action and another died from disease contracted in military service. At the special request of His Majesty's Government, one of the inspectors was granted leave and was appointed inspector of boilers by the War Department at the base for the term of the war.

The Chairman, in moving the adoption of the report, said that the figures given were proof of the Association's sound financial position. The Committee regretted that a life had been lost by the drawing out of a tube in a water-tube boiler, this being the first fatality that had occurred from any guaranteed boiler during the past 50 years (during which time the guarantee system had been in operation), but it was a consolation to know that it was not the fault of the Association.

Mr. Charles Heaton, Vice-President (Bolton), who has been a member of the Committee for 57 years, seconded the resolution, and referred to the fact that steam-users were increasingly coming to see the importance of securing safety by efficient inspection of their boilers rather than compensation for accidents. The Association had in the past made various experiments with regard to boiler construction, steel, fatigue tests, &c., many of the results of which the members present could see in the adjacent museum.

The resolution was then put to the meeting and carried unanimously.

On the motion of Mr. Edward Peers (Bury), seconded by Mr. W. A. Oglethorp (Mersey Docks and Harbour Board, Liverpool), the thanks of the Association were presented to the Committee for their past services, and they were reappointed for the ensuing year.

A vote of thanks to the Chairman was unanimously passed, after which a large number of the members present examined the many interesting specimens in the Association's museum, and also witnessed some simple but extremely instructive experiments in the laboratory.

ARKANSAS MANGANESE.—The Arkansas manganese field has been the scene of considerable activity during the last few months in consequence of the rapid advance in the price of ferro-manganese. The deposit is being worked rather crudely by reason of the want at present of concentrating machinery, but the ore, which promises good results from better treatment, is being held for future milling. About 10 cars per week are being despatched, mostly of high-grade ore, yielding in some cases as much as 60 per cent. in manganese. The area of the field is 260 square miles.

THE PHYSICAL SOCIETY OF LONDON.

AT the meeting of the Physical Society of London, held on May 26, at the Imperial College of Science, Professor C. V. Boys, F.R.S., President, in the chair, a paper entitled "*The Correction of Chromatic Aberrations when the External Media are Dispersive*," was read by Mr. T. Smith.

When one of the external media of a lens system is dispersive it is not possible to ensure the absence of differences in the size and position of images of all objects formed by length of different wave-lengths. The degree to which correction can be carried is investigated, and formulæ are given by which the power and position of the external surfaces of a system can be found when the type of correction to be adopted is given.

A paper entitled "*Note on the Use of the Auto-collimating Telescope in the Measurement of Angles*" was read by Mr. J. Guild.

The measurement of angles by means of the autocollimator resolves itself into the measurement of the distance between two images produced in the focal plane of a micrometer eye-piece. In most cases the light forming these images passes through portions of the object glass on opposite sides of a diameter. It is shown that, when this diameter is perpendicular to the direction of the displacement to be measured, uncertainty and error are introduced on account of any residual spherical aberration of the object glass and the depth of focus of the telescope. One or two particular cases are discussed in which it is shown how this may be obviated.

Discussion.—Dr. R. S. Willows asked why the Abbé type of autocollimating eye-piece, such as is used on Pulfrich refractometers, &c., was not employed in the arrangement described in the paper. The author explained that there was a difficulty in adapting this method of illumination to a micrometer eye-piece.

A paper entitled "*The Viscosity of Colloidal Solutions*" was read by Mr. Emil Hatschek. The author, in reply to some remarks made by Mr. W. B. Hardy in the course of his Guthrie lecture, points out (*a*) that no viscosity formula can cover the stage of gel formation, since the change from a liquid with only slight anomalies, to a system having many properties of an elastic solid, necessarily precludes this, and (*b*) that the formula given by Einstein, and independently by himself, for the viscosity of a suspension of rigid spherical particles, does not in any event apply to systems such as discussed by Mr. Hardy, which belong to the class known as emulsoids. In these both phases are quite generally assumed to be liquid, and an expression for the viscosity of such systems was deduced by the author in 1911, from a consideration of the deformation which a homogeneous polyhedral structure must undergo when sheared. The expression contains only the viscosity of the system and the phase ratio, but neither the interfacial tension of the phases nor the viscosity of the disperse phase. It can be tested directly for emulsions of two immiscible liquids; in the case of emulsoids, where only the weight of dispersed substance is known, some assumption has to be made about the relation between the volume of disperse phase formed—*i.e.*, the degree of hydration or solvation—and the weight dissolved. The simplest assumption, that this ratio is constant, has been tested by the author, and by Dr. Harriette Chick, for a number of sols, and is found to hold good over a considerable range. The formula has also been tested by F. Kirchhof in a different way, by comparing the degree of solvation—*i.e.*, the amount of solvent taken up by the disperse phase in different solvents—with the amount of the solvent taken up by the substance (india-rubber) in the swelling which precedes dispersion. Remarkable agreement both in the order and in the absolute amounts in different solvents was observed.

Discussion.—Dr. A. Griffiths said he was in emphatic agreement with the conclusion at the end of paragraph 2. He mentioned the case of a gelatine which would not run through a capillary tube, but which could be made to do so when broken up by stirring with a stick. He thought experiments on rigidity as well as viscosity should be made.

The author, in reply to a remark by the President, stated that accidental double refraction was sometimes observed in the liquid phase.

FREIGHT RATES AND FARES IN AMERICA.—According to a recent statement in the *Railway Age Gazette*, freight rates in America have during the past 10 years been reduced from an average of 7.48 mils per ton mile in 1906 to 7.33 mils per ton mile in 1914. The average passenger fare, which was 2.003 cents per mile in 1906, is now 1.982 cents. During the same period taxes have increased from 3.2 to 4.6 per cent. of the total earnings. The average compensation paid to employees is now 218 dols. more than in 1906. In the latter year 69 cents per dollar earned sufficed to pay operating expenses and taxes. This figure is now 77 cents per dollar.

OPENINGS FOR BRITISH TRADE.—The Commercial Intelligence Branch of the Board of Trade state that they have received applications from foreign firms and firms in all parts of the United Kingdom who wish to enter into communication with manufacturers of various classes of goods, among which are art paper machinery, briquetting presses, channelling machines, dividing engines, electric baling presses, engraving machines, ice-making machines, machines for extruding clay in thin strips, magnesia or fireclay rings and gas mantles, scrap-baling presses. If manufacturers of the above will communicate with us, we shall duly forward their information to the Commercial Intelligence Branch.

LABOUR EXCHANGES AND TECHNICAL STAFF APPOINTMENTS.

TO THE EDITOR OF ENGINEERING.

SIR,—The thanks of a whole crowd of draughtsmen and others are due to you for having enabled them to ventilate a very real grievance, but I think most of your correspondents have gathered an erroneous idea of the importance of the labour exchange manager. I take it that his duty is merely to weed out and destroy any applications from men engaged on war work, and to forward the rest to the firm advertising.

The greater grievance is that very many men who are *not* on war work have been badged and are thus debarred from applying for other positions.

In the particular department of the works where I have the fortune, or misfortune, to be employed 75 per cent. of the men are badged, yet only 25 per cent. of them are to any regular extent employed on munitions. In my own particular case, during the last three months, *only* 21 *hours* have been spent on munition work, yet I cannot apply for another post with any prospect of my application being considered. Anyone can quite see the necessity for some restrictions at a time like this, but the present system actually defeats its own object by locking up a goodly portion of the best skilled labour. This could easily be rectified if the Ministry of Munitions would establish a rule that no man should be entitled to a war service badge unless at least 50 per cent. of his time was spent on bona-fide war work.

Liverpool, June 5, 1916. BADGERED.

MUNITION WORKERS.

TO THE EDITOR OF ENGINEERING

SIR,—In your issue of June 2 you refer to the munition worker, devoid of knowledge and experience of mechanical matters, who presents himself at the gate of the works for a job, and who would have been informed in pre-war days that a five-year apprenticeship would be necessary. It is somewhat difficult to understand the reason for the surprise occasioned by the general invasion into engineering works, since it is clear that the potential munition worker possessing "a superficial acquaintance with tools and machines, and generally a fairly complete knowledge of one operation in shell manufacture," is far from having the skill, experience and craft-knowledge gathered by an artisan during a five-year apprenticeship.

Men and women have constantly been used for repetition work in the engineering industry without any special apprenticeship or training, and the Ministry of Munitions, in making no attempt to turn out skilled mechanics, is wise in refraining from attempting what is, in a limited period, the impossible. Thus "the average munition worker is quite incapable of tool-setting." It is becoming evident that what has happened in engineering shops resembles the state of affairs existing with regard to women workers in other branches. While there has been a tremendous expansion in numbers employed, there has been very little real substitution of skilled workers by this new and rapidly trained labour. The latter has been mainly utilised in those directions where it already existed prior to the war.

One important consideration arises, however, in the fact that specific training has been found necessary for men and women undertaking repetition work in order to mature them rapidly, and this suggests that, in future, training will be considered necessary for every job, however apparently "unskilled" it may appear. It therefore becomes desirable to formulate a broad scheme of training for industry to cover both professional workers and manual workers, based on the principle that differentiation of function involves differentiation in training. Such a scheme will involve primary education which will arouse and foster those qualities necessary in industrial life, and the careful selection of every boy for the job for which he is inherently most fitted, together with training based on a knowledge of the function he will exert. This will be largely a matter for the manufacturer, in the hands of whose assistants most of our industrial and trade experience lies.

It would be regrettable if the readiness with which repetition workers can be trained obscured in our minds the necessity of a long period for the development of the thoroughly skilled artisan, without whom the industry would inevitably suffer.

Faithfully yours,

J. G. PEARCE.

BOOKS ON THE IRON AND STEEL INDUSTRY.—The West of Scotland Iron and Steel Institute has issued a list of books relating to the iron and steel industry in eight libraries of the West of Scotland. It can be obtained at the Secretary's office, 124, St. Vincent-street, Glasgow, price 6d.

1ST LONDON ENGINEER VOLUNTEER CORPS.—The 1st London Engineer Volunteer Corps has been formed by the amalgamation of the E.I.V.E. Corps with the 4th Battalion Central London Regiment (Architects' Corps) and the L.C.C. Training Corps. The three corps have now, in accordance with the wish of General Sir O'Moore Creagh, become an Engineer Corps; with the exception of the Post Office Engineering Volunteer Training Corps (which is composed of Civil Servants) it is the only Engineering Corps in the Metropolitan area. The members will only be compelled to come out for service for the purpose of repelling an enemy in the event of an invasion being imminent and except on actual military service may quit the Corps by giving fourteen days' notice in writing and fulfilling a few other simple requirements. The address of the Corps is Chester House, Eccleston-place, S.W.

ELECTRICAL SWITCH-GEAR FOR INDUSTRIAL PURPOSES.

CONSTRUCTED BY THE ELECTRICAL APPARATUS COMPANY, LIMITED, ENGINEERS, LONDON.

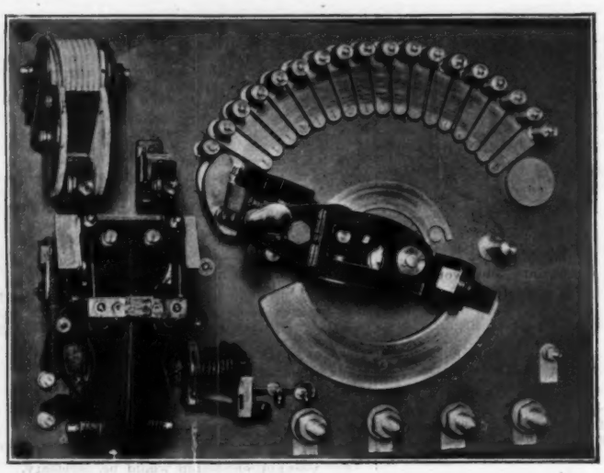


FIG. 1.

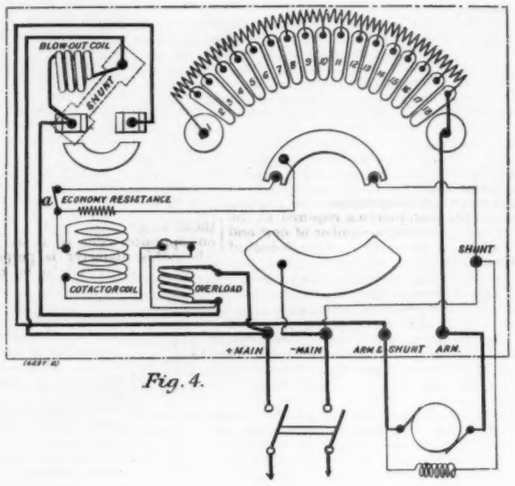


Fig. 4.

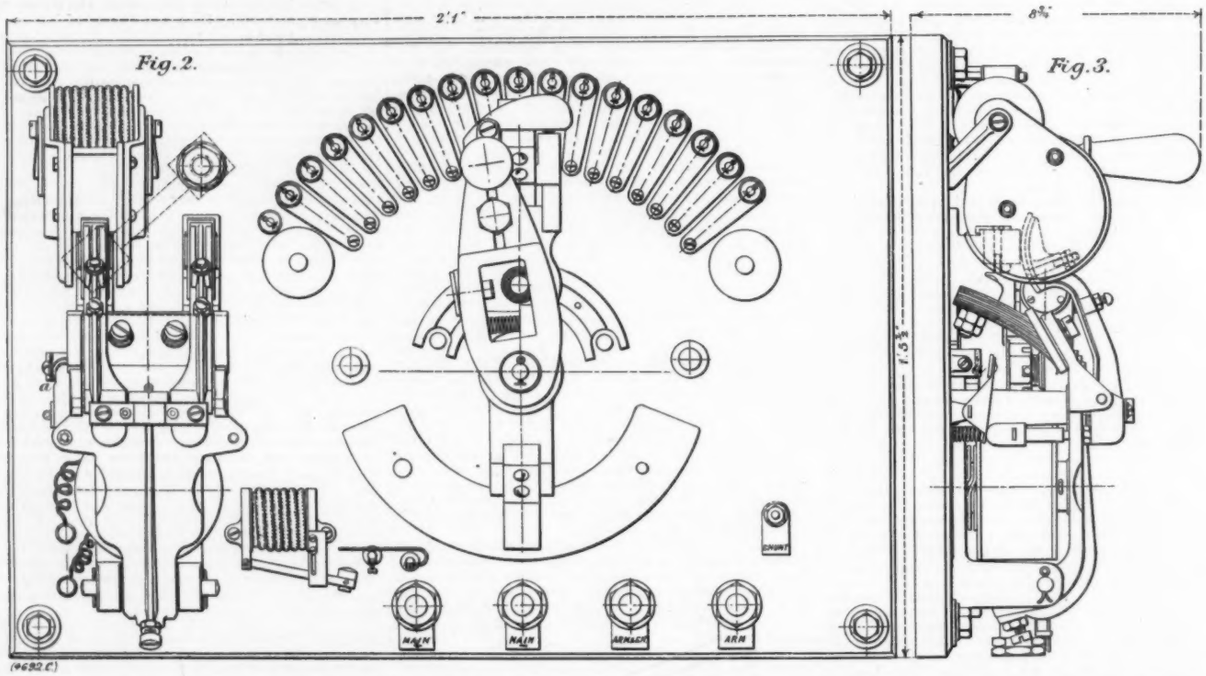


Fig. 2. *Fig. 3.*

(4682.C)

ALTHOUGH a great improvement in the design and construction of switch-gear for industrial purposes has taken place within recent years, reference to the statistics issued by insurance companies will show that failures of this part of the electrical equipment of factories still form a considerable proportion of the total number of breakdowns. This is largely due to the fact that low first cost has tempted the more short-sighted purchasers to install flimsily-constructed and over-rated apparatus for heavy work, with the result that the failure of some minor detail has caused serious loss by rendering expensive machinery idle. Such experiences, however, have resulted in a demand for high-class switch-gear, to which demand electrical manufacturers have not been slow to respond, so that the percentage of breakdowns from the cause we are referring to will undoubtedly diminish. Electric driving has, of course, been very largely adopted in the various armament factories that have been constructed in different parts of the country, as well as in the old-established works that have been adapted for the production of munitions of war. In such works the shortage of skilled labour has frequently rendered it necessary to place electrically-driven machinery in charge of unskilled or partly-skilled workers, and it is therefore essential, if continuous output is to be maintained, that the switch-gear employed should be of exceptionally substantial design and construction, so as to withstand a certain amount of abuse, in addition to the heavy work to which it is likely to be subjected. It must also be arranged to protect the motors and machinery, as far as possible, from the effects of careless handling.

On this page and on pages 553 and 556 we illustrate some examples of switch-gear designed and manufactured by the Electrical Apparatus Company, Limited, of Vauxhall Works, South Lambeth-road, London, S.W., which, we understand, are being successfully employed under the above-mentioned conditions in numerous munitions works and industrial concerns. Fig. 1 is reproduced from a photograph of the firm's heavy-duty "inching" starter, which is specially intended for use where continuous-current motors have to be started and stopped frequently under load. The most important feature in the design of this starter is that full protection from overloads and failure of the supply current is obtained during the process of starting, as well as while running, without the usual spring rheostat arm and hold-on coil. It is thus possible to increase the pressure between the brush on the arm and the contact segments sufficiently to obtain a really satisfactory contact. The angular movement of the arm may also be increased so as to spread the resistance over a greater number of steps; several other useful features of the design, all of which are covered by patents, will be referred to later. The construction of the starter is illustrated, in Figs. 2 and 3, and a diagram of the electrical connections is reproduced in Fig. 4. The starter illustrated comprises an automatic circuit-breaker, or contactor, by means of which the circuit is always made and broken, and a rheostat arm having a laminated copper brush at each end, one of which moves over the segments connected to the resistances, while the other bears on a solid brass sector connected to the negative main. The rheostat arm is moved by a cradle mounted on the same spindle as the arm and carrying the operating handle, a contact plunger on the inside of the cradle bearing against a copper pin on the rheostat arm when the cradle is moved in a clockwise direction, though these parts are normally kept out of contact by a small spring; an inspection of Figs. 1 and 2 will make this clear. The copper pin is insulated from the rheostat arm by means of an ebonite bush, and its lower end is fitted with a spring-plunger

ELECTRICAL SWITCH-GEAR FOR INDUSTRIAL PURPOSES.

CONSTRUCTED BY THE ELECTRICAL APPARATUS COMPANY, LIMITED, ENGINEERS, LONDON.

Fig. 5.

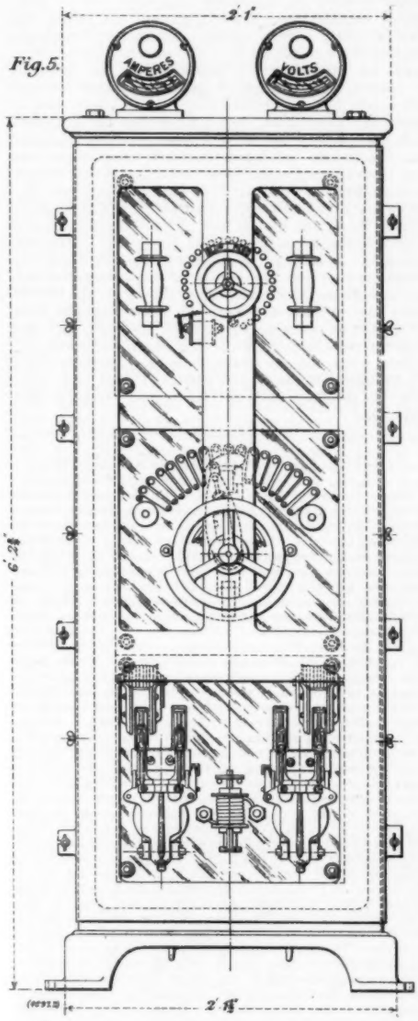


Fig. 6.

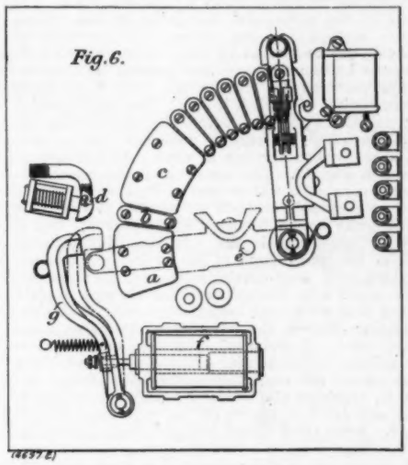
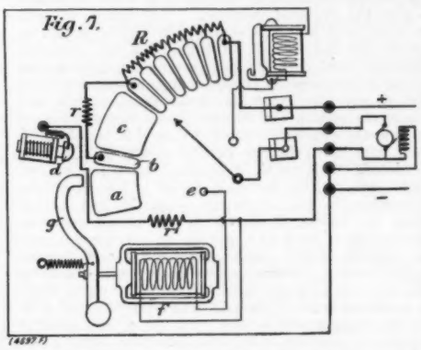


Fig. 7.



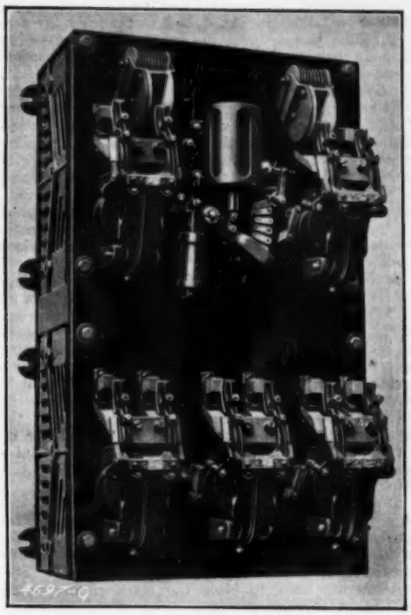


FIG. 8.

bearing a brass sector fixed to the slate base. Reference to the wiring diagram, Fig. 4, will show that this sector is connected through an economy resistance to one terminal of the electro-magnet operating the contactor, and that another connection is made to the same terminal from a button contact at the left-hand end of the sector. It should also be noticed that the latter connection is only made if a small switch, lettered *a*, is closed, and that the other terminal of the magnet coil is connected to the positive main through the overload release. Now suppose that the rheostat arm is in the position shown in the photographic illustratiom, Fig. 1, the plunger on the rheostat arm then being partly on the button contact, above referred to, and partly on the sector; if the double-pole main switch, indicated diagrammatically at the bottom of Fig. 4, is then closed, nothing will happen, and no current will flow through any part of the apparatus until the starting-handle is moved so as to bring the plunger on the inside of the cradle into contact with the copper pin on the rheostat arm. When this has been done the circuit through the contactor magnet and switch *a* is completed, so that the magnet is energised and the contactor closed, thus allowing the current to flow through the whole of the resistance to the armature of the motor. The action of closing the contactor, however, opens the small switch *a* by a simple mechanical device, which is best shown in Fig. 3. Current to the contactor magnet must then pass through the economy resistance, so that it is impossible to burn out the coil by remaining too long on the first contact. By continuing the movement of the starting-handle the resistance is gradually cut out in the usual manner; but if the handle is released, or moved in the wrong direction, during the process of starting up, the contactor-coil circuit will be broken and the contactor opened, thus breaking the main circuit. It is impossible to start up again without going back to the first contact, because when the economy resistance is in series with the coil of the contactor magnet, the latter is not sufficiently powerful to pull up the contactor arm from the open position, although it is capable of keeping the arm in the closed position. When the arm is on the last contact, and the motor is running at full speed, the handle can be released without opening the contactor, because, in this position, the plunger on the rheostat arm rests on a second button contact at the right-hand end of the sector, and a connection is thus made to the negative main independently of the contact in the cradle. If the starting-handle is moved too rapidly over the resistance contacts, the excessive current would operate the overload release, thus breaking the circuit of the contactor magnet, and the same effect would be produced by an overload on the motor while running. Failure of the supply would also, obviously, open the contactor, so that no damage would be done when the supply was restored. The design of the contactor is clearly shown in Figs. 2 and 3. It will be seen that the armature of the magnet carries a heavy copper plate, which, in the closed position, bridges across a pair of laminated copper brushes. Two long breaks are thus obtained instead of one, and, at the same time, the use of flexibles to carry heavy currents continuously is avoided. When the contactor is opened the circuit is broken on a pair of renewable copper-carbon contacts, one of which is provided with a magnetic blow-out for the purpose of destroying the arc formed. The resistance contacts are protected from burning by providing each of them with a copper roller, with which a spring-arm makes contact in advance of the brush on the rheostat arm. Any sparking that may occur is therefore confined to the rollers, which can easily be replaced and cannot be broken, as carbon rollers might be. Starters of this type are made in various sizes for motors ranging from 5 to 200 horse-power, and for pressures up to 550 volts; the resistances used are all of "one-minute" controller rating. The starters can be supplied either in the open form, as illustrated, or in the enclosed form with glass inspection-windows, and external operating-handles.

A complete motor-starting panel made up in the latter form is illustrated in Fig. 5. As will be seen, it includes an "inching" starter with two single-pole contactor switches, a field regulating rheostat, two single-pole fuses of the porcelain-handle type, and an ammeter and voltmeter mounted on the top of the casing. Such panels are very convenient and serviceable for use in factories and engineering works.

In Fig. 6 we illustrate a patented form of starter for use with a 10-horse-power series-wound motor driving a centrifugal machine. The general design of this starter follows the more usual lines—that is to say, the rheostat-arm is held in the full-on position by an electro-magnet, and returned to the off position by means of a spring. It includes, however, some interesting features, designed to meet the particular conditions of the service for which it was employed. One of these conditions was that the motor should be capable of running at a very slow speed for a comparatively long period during the process of filling the centrifugal, and another was that it should be impossible to move the starting-handle, after cutting off the current, until the motor had come practically to rest. How these requirements were met can best be followed from the wiring diagram of the starter reproduced in Fig. 7. To meet the first-mentioned condition, that of slow running, a special contact *b*, with an auxiliary resistance *r*, was provided, and placed in such a position that the momentum of the rheostat arm, if released by the operator when on the first main resistance contact, would be sufficient to carry the arm past the special contact into the off position. For this reason it was necessary to place the contact at a considerable angular distance from the main resistance contacts, and in order to carry the rheostat arm smoothly over the intervening space the large dead-plate *c* was inserted. When the rheostat-arm is on the contact *b* it is also in electrical connection with a spring-plunger contact *d*, connected through another auxiliary resistance r^1 to the motor-field winding, and thence to the negative main. In this position current from the positive main passes through the starting resistance, and the auxiliary resistance *r*, to the contact *b*, and then divides and flows partly through the rheostat arm to the motor armature, and partly through the plunger-contact and resistance r^1 to the field-winding. A strong field and weak armature current, which are the conditions necessary for slow-speed running, are thus obtained. The motor can be run up to full speed by moving the starting-handle into the full-on position, in which it is held by a pin engaging with a trigger formed on the armature of the holding-on magnet. On opening the main switch to stop the motor the handle is released and flies back on to a dead-plate *a*. In this position the arm rests on a button contact *e*, and so connects the solenoid *f* to the motor terminals, as

is clearly shown in Fig. 7. While the armature continues to rotate the remanent magnetism of the motor-field is sufficient to produce an electromotive force, which energises the solenoid *f* and pulls up a catch *g* against the action of a spring. This catch engages with the end of the rheostat arm, as indicated by the chain-dotted lines in Fig. 6, and so prevents the arm from being moved until the speed of the motor has dropped below a predetermined limit; the actual speed at which the arm is released is about 1 per cent. of the normal. The object of the device is to prevent the sudden slowing that would otherwise occur if the starting-handle were moved into the slow-running position while the machine was still running at a high speed due to its own momentum. The principle of making use of the back electromotive force of the motor to operate some form of safety device, such as that above described, can, of course, be applied to the "inching" starters, and also to automatic panels, or any other form of control-gear, with obvious modifications in detail.

A photograph of one of the firm's automatic starting-panels, which can be supplied for use with motors up to 500 horse-power, is reproduced in Fig. 8. Starters of this type find numerous applications in war work on account of the extreme simplicity of the starting operation, which is effected by the closing of a single switch. They are suitable for use with motor-driven pumps, hydraulic accumulators, air-compressors, machine-tools, hoists, printing-presses, &c., and the single switch may be operated either by hand or by a float, tappet-rod, pressure-regulator, or other automatic device placed at any distance from the motor. With printing-presses, machine-tools, hoists, &c., a "stop and start" push-button switch is often employed with these automatic starters. The starter consists of a number of magnetically-operated contactor switches, similar in design to those described above in connection with the "inching" starter, and these switches are used to close the main circuit of the motor and to short-circuit sections of the resistance until the motor is running at full speed. By closing a switch, or pressing a push-button, a solenoid, shown in the illustration, is energised, and this pulls up a lever, the end of which moves slowly over a number of contacts, the rate of movement being governed by an oil dashpot. When the lever reaches the first contact, the electro-magnet of the main contactor switch, which is the one on the left-hand side of the solenoid, is energised, thus closing this switch and completing the circuit through the armature of the motor. At this stage all the starting resistance is in series with the motor, but as the lever operated by the solenoid travels over the contacts, the other contactor switches are closed in succession, and these short-circuit sections of the resistance until finally the main switch on the right of the solenoid is closed, and the whole of the starting resistance is cut out. As will be seen, the main switches are fitted with magnetic blow-outs, but on the intermediate switches these are unnecessary. As each of the contactors is closed, a resistance is put in series with the operating-coil by means of a small switch, similar in design to that lettered *a* in Figs. 2 and 3, so that there is no possibility of the coils being burnt out. The solenoid is also provided with an economy resistance, which is put into circuit by means of the small tappet-switch seen in the illustration on the right-hand side of the solenoid, near the last contact. The number of resistance sections used, of course, depends upon the power of the motor, and the rate of acceleration is arranged to suit the load by adjusting the dashpot. A special automatic device can, however, be added to vary the period of acceleration to suit varying starting conditions. When this is used the dashpot is adjusted to cut out the resistance sections as quickly as is permissible, and, after one section has been cut out, a series relay prevents the next section from being short-circuited until the armature current has dropped to some predetermined value. Overload protection is obtained by means of external circuit-breakers or fuses, and as failure of the current will cause the contactors to open, and also allow the contact lever to fall into the off position, no other "no-voltage" protection is necessary. The switches are interlocked in such a manner that the first main contactor can only close if all the others are open and the contact lever is in the off position.

Of the other illustrations, Figs. 9, 10 and 11, page 556, are reproduced from the drawings of an ironclad oil-switch suitable for factory and mining work, under most severe conditions, with three-phase current up to 650 volts. They can, however, be made suitable for pressures up to 3500 volts by fitting teak arcing-screens between the phases; with the exception of such screens, the insulation and creeping surface of the low-tension switch have been designed so as to be sufficient for the higher voltage. Fig. 12 is a photographic illustration showing one of the switches mounted on a cast-iron pedestal, and provided with draw-out isolating gear and a tank-lowering device. As will be seen, the switch is totally enclosed, and the cast-iron casing is made in three parts, having very broad flanges, held together by bolts fitted with wing-nuts. The flanges, which are 1¼ in. wide, are machined for use in fiery mines, and, if necessary, the casing can be strengthened by ribs to render it explosion-proof. The whole of the mechansim is carried by the central section, so that the lower section, which forms the oil reservoir, can be lowered by simply removing the bolts from the bottom flange. An interlock is, however, always provided to prevent the tank from being lowered unless the switch is open. The upper section may consist of a plain flat cover, or may be of the hooded form illustrated, to enclose measuring instruments, which are visible through a wired-glass window, as shown in Fig. 12. The switch is of the horizontal-drum type, and, as will be seen in Figs. 9 and 10, the fixed and movable contacts are carried on steel bars of triangular section, insulated with micanite; this, it may be mentioned, is the only insulating material used in the construction of the switch. When not provided with draw-out isolating-gear, the incoming main is led into the switch either through a plain bushed hole or a hole tapped to receive the cable-protecting conduit, the latter being the most usual arrangement; if armoured cables are used, suitable sealing-boxes and armouring-clamps are supplied. The three phases are connected to terminal clamps and sockets, which are also carried by insulating triangular bars, and are best shown on the right-hand side of Fig. 9. From these terminals copper strips lead to the contact-fingers, which are of the spring-plunger type, and can be adjusted by means of a screw and nuts to give the required pressure. The design of both the fixed and movable contacts is clearly shown in Fig. 9, and the method of supporting the insulated triangular bars, on which they are mounted, from lugs on the central section of the casing, is well shown in Figs. 10 and 11. From the fixed contacts on the load side of the switch the current passes through copper strips to the overload coils, and thence to terminals to which the three phases of the outgoing cable are connected. This cable leaves the switch on the opposite side to the incoming cable. The operating mechanism is best shown in Figs. 10 and 11, in which the switch is drawn in the closed position. The handle is fixed to a spindle by a taper pin, and the spindle, which passes through a boss formed on the casing, carries on its inner end a casting with two radial arms, in one of which a pin is fixed at right angles. This pin, which is lettered *a* in Fig. 11, engages with a catch on a link *b*, connected to a casting *c* mounted on the triangular bar carrying the moving contacts. If the handle is pulled downwards to open the switch, the pin *a* slips out of the catch on the link *b*, and allows the larger of the two helical springs shown to rotate the casting *c*, and consequently the triangular bar carrying the movable contacts, through a right angle in a clockwise direction, thus opening the switch. The angular movement of the movable contacts is limited by a buffer *e*, formed of two sets of laminated steel plates, between which a wedge-shaped projection on the casting *c* enters when the switch is fully opened. The arrangement, it will be seen, gives a long double break on each phase, the actual head of oil between the contacts being over 3 in. when the switch is open. The object of the smaller spring is to pull the link up on to a stop *d*, in which position the pin *a* can be made to engage with the catch on the link when it is required to close the switch. For this purpose the handle must be brought right down to the vertical position, and then, by bringing the handle up again, the parts can be restored to the positions shown in Fig. 11. The action of the overload release will be best understood by an inspection of Figs. 9 and 11. In the event of an overload the plungers of the solenoids shown in Fig. 9 will be pulled upwards, thus rotating a triangular bar *f*, to which they are connected, in a clockwise direction. The end of the bar carries a trigger *g* (Fig. 11), and the movement of this trigger releases a weighted lever *h*, which falls on to the link *b*, and knocks it out of engagement with the pin *a*, thus allowing the large spring to open the switch. From this it will be evident that it is impossible to hold the switch closed on a fault. Before the switch can be closed again it is necessary to re-set the weighted lever *h*, and this is accomplished by moving the operating handle down to the vertical position, and thus raising the weighted lever by means of the arm *j*. The overload release can be adjusted to operate at any given current by means of a screw bearing on a small lever, lettered *k* in Fig. 10, mounted on the end of the bar *f* outside the switch; the same lever can be used to trip the switch by hand at any time. No-voltage protection is obtained by another solenoid, not shown in any of the drawings, which is arranged to release the weighted lever and open the switch, in a manner similar to that described in connection with the overload release, if a failure of the supply current should occur. When provided with draw-out isolating gear, as illustrated in Fig. 12, the incoming and outgoing cables are each connected to a set of three sockets on the pedestal. Two sets of plugs, mounted on the back of the casing and connected to the fixed contacts of the switch, fit into the sockets when in the working position, but by drawing the switch forward on rollers the apparatus can be completely isolated from the live parts; the casing can then be safely opened for the examination or adjustment of the working parts. The interlocking arrangements are such that it is impossible for the casing to be opened until the switch has been drawn forward sufficiently to separate the plugs and sockets, and so render the parts dead, or for the switch to be pushed back until all the covers have been replaced; neither can the switch be drawn forward when closed, so that there is no possibility of the circuit being broken on the plugs and sockets. The tank-lowering arrangements are practically self-explanatory, the tank being lowered on to the foot of the pedestal by means of a hinged wrought-iron frame, and being kept horizontal during the operation by vertical rods fixed to the central section of the casing, and passing through bosses cast on the tank. For pressures up to 650 volts, the switches are made in three standard sizes for maximum working currents of 100, 150, and 300 amperes respectively, while for other pressures, up to 3500 volts, the one size made is capable of handling a maximum current of 125 amperes; they can, however, be specially designed for higher pressures and currents.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—The demand for best hards, common hards, nuts, cobbles and slacks remains abnormally high, and no reserves are allowed to accumulate at the pits. Local works are taking all possible supplies and collieries find the daily output absorbed by contracts, with the result that there is practically nothing available for the open market. Railway companies are large customers for best steam coal. There is considerable briskness about the shipping section. Now that prices are regulated for this trade also, the problem resolves itself into one of supplies. The Allied Powers are anxious to lay in stocks for the winter season and, accordingly, there is a heavy pressure on export business. Neutrals are making persistent inquiries for South Yorkshire hards, but with little success, even though as much as 38s. per ton at pit is the tempting price offered. Gas companies do not find the market favourably disposed to accommodate them with the many thousands of tons of coal they require to bring their stocks up to the summer level. Some negotiations are taking place between the gas-coal producers and the Government with respect to the price of gas fuel. The last contracts were entered into before the Coal Prices (Limitation) Act intervened, and it has been a moot point ever since whether the prices then quoted were not too high. The present difficulties centre around the producers' demand for an extra 1s. on the last list. The house coal position finds dealers with an abundance of orders, especially for the time of the year. The Sheffield Chamber of Commerce yesterday decided to send a letter to the Board of Trade, impressing upon them the great importance of ensuring an efficient supply of coal for the purposes of manufacturing, as well as for the manufacture of gas, which is so largely used in the various Sheffield works. Quotations: Best branch hand-picked, 20s. 6d. to 21s. 6d.; Barnsley best Silkstone, 18s. 6d. to 19s. 6d.; Derbyshire best brights, 17s. 6d. to 18s. 6d.; Derbyshire house, 16s. to 17s.; best large nuts, 15s. 6d. to 16s. 6d.; small nuts, 15s. to 16s.; Yorkshire hards, 16s. 6d. to 17s. 6d.; Derbyshire hards, 16s. to 17s.; best slacks, 12s. to 13s.; seconds, 11s. to 12s; smalls, 8s. to 9s. per ton.

Iron and Steel.—Steel works extensions are taking place at many of the largest establishments in the city and the latest reported developments concern the Parkgate Works, which are to be greatly enlarged as a result of the present operations. This is welcome news, for the demand for manufactured steel increases at an extraordinarily rapid rate. There is still a general shortage of material. Pig-iron is very scarce, particularly hematite qualities, which meet with a constantly-growing inquiry. The foundry iron supply is none too plentiful, but it is reported that the furnaces and foundries are not receiving sufficiently large orders to keep them working at full pressure. For the general trade there is a difficulty in securing basic billets, especially so with the reduction of the American supplies. Soft and hard qualities are quoted by makers at the official maximum of 11*l.*, but at this figure they are giving no guarantee of delivery at a specified date. The Government scheme for the maxima of prices for the scrap trade has not yet matured. There is a good market for heavy steel scrap, both for melting and rolling, at from 5*l.* to 6*l.* 10s., and for good old wrought iron, which realises full 6*l.* 10s. to 7*l.* Buyers are loth to pay such heavy prices on the ground that they are excessive. Good business is also being done in the ends of shell bars and defective billets. The high-speed steel output now touches a tremendous figure, much to the gratification of the Ministry of Munitions, which realises the importance of tool steel in the munitions output. Something must be done, however, to ensure more regular and systematic supplies of tungsten, for the quantities arriving are not equal to supplying high-speed steel makers with all the raw material they can deal with. Rolling mills and plants are congested with orders. Finished goods of considerable aggregate value are being held up in their transport to Russia, and other

overseas markets, for the want of the necessary shipping facilities. Garden-tool prices have risen fully 50 per cent. on the year on account of the labour troubles manufacturers are experiencing and also the heavy cost of materials. There is still the greatest difficulty in securing supplies of handles. The new overseas orders include large quantities of steel, tools, plane irons, machine knives, saws, cutlery, and electro-plate.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Glasgow Pig-Iron Market.—Brief and bald seems the statement that the meetings of the Glasgow pig-iron warrant market have been suspended meantime; but the fact that the operations of the iron "ring" have come to even a temporary cessation undoubtedly marks one of the most drastic changes occasioned in Glasgow business circles through the exigencies of the war. The ban placed by Government some months ago upon speculative dealings in pig-iron and other metals has been most effective in its results, and during the past few weeks at least no business has been done, at any rate in the open market. This, however, will in no way interfere with the actual consumption of No. 3 iron, which has long been the centre of speculative activity, but in future warrants may only be dealt in against an order for home or export trade.

Scotch Steel Trade.—Perhaps no greater impetus to trade and commerce connected with war work generally could have been given than the naval engagement of a week ago, and now, as doubtless never before, the workers engaged in the steel and iron industries realise how very much depends upon their efforts if the war is to be brought to an expeditious and successful termination. To speed up the output seems the laudable and patriotic desire of all concerned, and "full steam ahead" is the policy in every engineering and steel-making establishment in the West of Scotland. Government continues more and more to absorb all the available output, and the many workshops engaged on contracts, directly or indirectly required for war purposes, are taking a specially active part in the gigantic struggle. It would seem almost as if the demand for shell bars would never cease, while practically the entire output of light plates and light sections is being absorbed by our own and the French Governments. Indeed, all classes of steel are being shipped to France in enormous quantities, otherwise the export trade remains quiet, although fairly satisfactory under existing circumstances. Meantime, too, orders for ordinary mercantile business are quite a hopeful feature. Although officially controlled, home prices keep firm, but a visible hardening is noted in the case of export business; this is attributed to the growing strength of pig-iron. For ship-plates the current rate is 14*l.* 2s. 6d. per ton f.o.b.; boiler plates are 15*l.*, or even more; and angles are, roughly, 14*l.*

Malleable-Iron Trade.—The malleable iron-trade is still booming, and the greatest activity prevails, for the demand is pressing, and the output cannot keep pace with it. Both our own and some of the Allies' Governments are steady customers, and their wants must be supplied with the utmost possible despatch. For prompt delivery "Crown" bars may still be had at 14*l.* per ton, but 14*l.* 5*s.* is readily quoted and obtained for some of the better qualities.

Scotch Pig-Iron Trade.—Business in the Scotch pig-iron trade continues unabated, makers being practically surfeited with orders for all grades, and more particularly for hematite, which is in extraordinary demand. In order to deal with this condition of affairs, a strenuous endeavour is being made to start up again various blasting furnaces, which had to be shut down some time ago on account of the labour difficulty. The increasing scarcity of No. 1 iron is responsible for the fact that the entire output of hematite is despatched to the steel works with all possible speed. For foundry iron also the demand is strong, and the price has hardened considerably, some brands to the extent of 5s. per ton. Prices for makers' (No. 1) iron still remain at last week's level.

Glasgow Fair Holidays.—So far no definite decision has been arrived at regarding the postponement of the annual holiday, although meetings have been held, and resolutions passed. While the majority of the men appear willing and anxious to fall in with the recommendations of the Ministry of Munitions, the various trade unions seem, meantime, to be the stumbling-block. Last week's naval engagement has made a profound impression upon the Clyde workmen, who are now more determined than ever to do everything in their power to crush German militarism and oppression.

RICE MACHINERY IN COCHIN CHINA.—There is beginning to be a demand in Cochin China for small rice-mills of the type so common in Burma, says the *London and China Telegraph*. Hitherto, according to the American Consul at Saigon, the Annamite rice-growers have sold their paddy on the ground to the Chinese rice-mill operators, or have delivered it to the mills. These large mills, nine in number, are located at Cholon, the Chinese suburb of Saigon. Before the war two of these mills were controlled by a German firm, but since the dissolution of the operating firms, and the consequent sale of the mills, the rice-milling industry of Cochin China is in the hands of the Chinese. The smaller rice-growers are financially dependent on these rice-mill operators, who advance them money for the marketing of their paddy, sometimes a year in advance; but many of the larger growers have sufficient capital to instal small mills of their own.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Owing to the continued shortage of supply of pig-iron, the heavy demand can only be fractionally satisfied. Little or no Cleveland pig is now purchasable for June delivery, but a fair amount of business for forward delivery is passing, buyers being anxious to place orders over the third quarter of the year. Makers, however, are very cautious in their dealings, and are not disposed to commit themselves far ahead, with the result that consumers, as a rule, are allocated only sufficient supplies to meet their actual requirements over a short period. No. 3 Cleveland pig-iron stands at 82s. 6d. delivered this month for home consumption, but the quotation is all but nominal. For delivery for home use beyond June the price of No. 3 is 87s. 6d. As regards sales to foreign countries, business is practically at a standstill. All output is implemented for home use and for covering shipments to the Allies under contracts already made. In the continued absence of transactions the export quotation of 100s. for No. 3 is purely nominal. The lower qualities are all round about the same prices as those named for No. 3, and No. 1 is put at 4s. to 5s. above the No. 3 quotations.

Hematite Iron.—With the scarcity of East-Coast hematite more pronounced than ever, business is almost impossible in this branch. There is no iron to sell for export, and, in fact, some parcels intended for shipment have been taken by the authorities for home use. Local consumers report that they are getting supplies fairly regularly, but the promised increased output is as eagerly awaited by them as it is by other customers. The price of Nos. 1, 2, and 3 for home consumption is 122s. 6d., and for export mixed Nos. are nominally 140s.

Stocks and Shipments of Pig-Iron.—Stocks of pig-iron are very low, and, in fact, the only iron of any consequence that is laid by is the Cleveland pig in the public warrant stores. The quantity so held is now only 31,392 tons, composed of 29,821 tons of No. 3, and 1571 tons of other qualities of iron deliverable as standard. Since the beginning of the month 1869 tons of No. 3 have been taken from the stores, and 45 tons of standard iron have been added, giving a net reduction of 1824 tons. Shipments of pig-iron from the port of Middlesbrough so far this month are officially returned at 9135 tons, as compared with 17,335 tons to the same date last month, and 1955 tons for the corresponding part of June last year.

Coke.—The supply of coke is hardly adequate to demand. Local needs are heavy and promise to increase, and demand for delivery elsewhere is good. Average blast-furnace kinds are 28s. at the ovens; best foundry sorts, 45s.; and gas coke, 27s. and upward, according to place of delivery.

Foreign Ore.—Foreign ore shows a marked upward tendency, notwithstanding the fairly good stocks held and the very satisfactory supplies coming steadily to hand. The f.o.b. price at port of despatch of Rubio of 50 per cent. quality is now 19s. 6d., and on the freight basis of 17s. Bilbao-Middlesbrough, the rate at which the Government enable controlled consumers to arrange steamers, sellers are quoting 36s. 9d. ex-ship Tees. In the open market, however, the freight from Bilbao is 19s., so that in the ordinary way the ex-ship Tees price of best Rubio should be 38s. 6d. to 38s. 9d. Imports of foreign ore to the Tees so far this month amount to 61,067 tons.

Manufactured Iron and Steel.—Very little new is ascertainable concerning the various branches of the finished iron and steel industries. Manufacturers are still too absorbed with work for the Ministry of Munitions to pay much attention to the rather numerous ordinary commercial inquiries that are in the market. Packing iron and steel (tapered) has been advanced, as have also iron and steel rivets. Principal market quotations stand: Common iron bars, 13*l.* 15s.; best bars, 14*l.* 2s. 6d.; double best bars, 14*l.* 10s.; treble best bars, 14*l.* 17s. 6d.; packing iron and steel (parallel), 10*l.*; packing iron and steel (tapered), 12*l.* 10s.; iron ship-plates, 11*l.* 10s.; iron ship-angles, 13*l.* 15s.; iron ship-rivets (¾ diameter), 17*l.*; iron ship-rivets (⅝ diameter), 18*l.*; steel bars (no test), 14*l.* 10s.; steel ship-plates, 11*l.* 10s.; steel ship-angles, 11*l.* 2s. 6d.; steel ship-rivets (¾ diameter), 18*l.*; steel ship-rivets (⅝ diameter), 19*l.*; steel sheets (singles), 18*l.* 10s.; steel sheets (doubles), 18*l.* 15s.; steel strip, 17*l.*; steel hoops, 17*l.* 10s.; steel joists, 11*l.* 2s. 6d.; and heavy steel rails, 10*l.* 17s. 6d.

Whit Monday Holiday.—The Cleveland ironstone mine-owners and the miners' representatives have agreed that whilst it may be desirable to work some of the mines on Monday next, it will not be necessary in all cases, and that where men are called upon to work additional payment shall be made on the following scale:—16 years of age and under, 1s.; 17 years of age and over, 2s.

NOTES FROM THE SOUTH-WEST.

Cardiff.—The steam coal trade has been quiet, buyers and sellers not being disposed to enter into fresh transactions pending the arrangement of details in connection with the limitation of prices for France. High-class coal has been quoted with some firmness, but other descriptions—and particularly smalls—have shown a drooping tendency. House coal has exhibited some strength, but other bituminous descriptions have been weaker. Patent fuel and coke have shown firmness. The best Admiralty large steam coal has been, to some extent, nominal; secondary qualities have made 53s. to 55s.; Monmouthshire Black Veins, 52s. to 52s. 6d.; ordinary Western Valley, 50s. to 52s.; Eastern Valley, 48s. to 50s.; best bunker smalls, 30s. to 32s.; and cargo smalls, 20s. to 22s. 6d. per ton. In bituminous, good households have made 23s. to 24s. per ton at the pits; No. 3 Rhondda large, 50s. to 55s.; smalls, 33s. to 35s.; No. 2 Rhondda large, 45s. to 47s.; and No. 2 smalls, 24s. to 25s. per ton. The latest quotation for patent fuel has been 50s. to 55s. per ton. Special foundry coke for export has realised 62s. 6d. to 65s.; good foundry coke, 60s. to 62s. 6d.; and furnace coke, 50s. to 55s. per ton.

Welsh Coal for France.—In connection with the official limitation of the price of coal taken for export to France a recently appointed committee of Welsh colliery-owners has (subject to the approval of the Board of Trade) fixed rates as follows:—Anthracite nuts and cobbles, 42s. 6d. per ton; anthracite beans, 35s. per ton; and anthracite peas, 20s. per ton. Maximum prices, as fixed; are free on board at the nearest customary shipping port; on coal sent elsewhere extra railway and shipping charges are to be added. Patent-fuel manufacturers have agreed to a maximum price of 30s. per ton for fuel for the French market, with 1s. per ton extra for exporters' remuneration, subject to coalowners agreeing to supply small coal for the manufacturers at a maximum price of 20s. per ton. The price-limitation policy of the Board of Trade will not be confined to Welsh coal, but will be extended also to Scotland and the East Coast. Pending the final working out of the official arrangements, business between buyers in France and British exporters is to be conducted in the usual manner, at prices, freights, and remuneration as set out in the official scheme.

Western Trade Matters.—The directors of the Newport Abercarn Black Vein Steam Coal Company, Limited, recommend a dividend of 12½ per cent. upon the ordinary shares for the past financial year. The ordinary dividends for the five years ended with March, 1916, were:—1912, nil; 1913, 4 per cent.; 1914, 10 per cent.; 1915, 10 per cent.; and 1916, 12½ per cent.—Negotiations are pending for the acquisition by the Ebbw Vale Steel, Iron and Coal Company, Limited, and T. Beynon and Co., Limited, of the Powell Tillery Steam Coal Company, Limited, which owns extensive coal-takings, &c., at Abertillery and Abersychan. The Powell Tillery Company was formed in 1904; it has a share capital of 144,000*l.*, and a debenture capital of 65,200*l.* Its present output is 900,000 tons per annum; this total is expected to be increased by future developments. T. Beynon and Co., Limited, is a private company, established about 70 years ago, at Newport, by Mr. T. Beynon. It holds several important coal sales agencies, and should the arrangements now projected be carried out, it will obtain a direct control over about 6,000,000 tons of coal annually.—The Pyman Steamship Company, Limited, reports a profit balance of 165,078*l.*, and it is proposed to pay 35 per cent. for 1915-16, carrying forward 23,162*l.*—The dividend on the ordinary shares of the Ebbw Vale Steel, Iron and Coal Company, Limited, for 1915-16 is at the rate of 10 per cent. per annum, as compared with 7½ per cent. per annum for 1914-15; 10 per cent. per annum for 1913 and 1914, and 3 per cent. per annum for 1912; an allocation of 3932*l.* is also made this year to the reserve fund, and 9299*l.* is carried forward.—Mr. J. A. Foote, of St. Helens, has been elected Chairman of the Neath Harbour Board, in succession to the late Mr. A. T. Williams. A payment of 2½ per cent. is to be made on Neath Harbour bonds for the past 12 months.

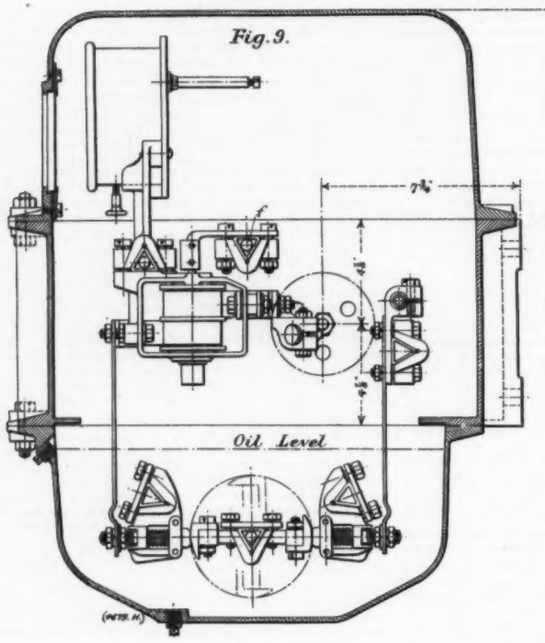
EXTENSIVE STATE RAILWAY CONSTRUCTION IN SWEDEN.—The Swedish State Railway Department has now completed its detailed plan for the completion of the great inland or central trunk railway, with branch lines, the aggregate cost of which amounts to 4,500,000*l.* The plan deals with the period 1917–27, and comprises partly the completion of the State railway sections now in course of construction, Ulriksfors-Volgsjön and Sveg-Brunflo and the branch line Sveg-Hede, decided upon but not yet commenced, and partly the following sections and branch lines:—The inland railway between the Angerman River (Volgsjön) and Gellivare, the Torsmo Hoting railway, the Hällnäs-Lycksele-Stensele railway, the Jörn-Afvaviken railway, and the continuation of the Umla railway as far as Härnösand. According to the plan the inland railway should be provisionally open from the south to Vilhelmina in 1917, to Stensele in 1918, to Sorsele in 1920, to Afvaviken in 1921, and from the north to Jockmock in 1922, its entire length in 1924, and completely finished in 1925.

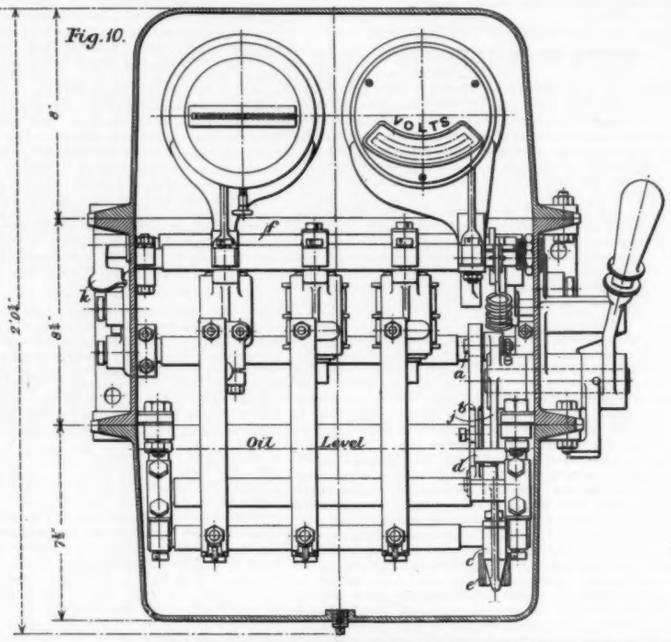
LARGE WAR PROFITS IN GERMANY.—There have been several striking examples of the enormous profits some German manufacturers engaged in the making of war requisites are making at the present time, but those of the Hirsch Copper and Brass Works are probably a record. The company is not a very large one, its capital being only 10,000,000 marks, but its profits during 1915 amount to 13,299,612 marks, against 3,511,894 marks for 1914, and over 2,000,000 marks for 1913. The profits are applied as follow:—Various writings off, 2,380,380 marks, against 367,293 marks for the preceding year, in addition to which ordinary business expenses and war-aid funds absorb 2,380,380 marks, leaving net profits available amounting to 8,879,445 marks, against 1,869,438 marks for 1914. A sum of 1,200,000 marks is reserved for different welfare and war purposes, against 150,000 marks for the previous year; 4,000,000 marks are applied to a special war reserve; 1,050,002 marks are added to the two reserve funds, against 242,295 marks in 1914; and 200,000 marks to the debenture account; and the shareholders obtain a dividend of 18 per cent., against 8 per cent. for 1914.

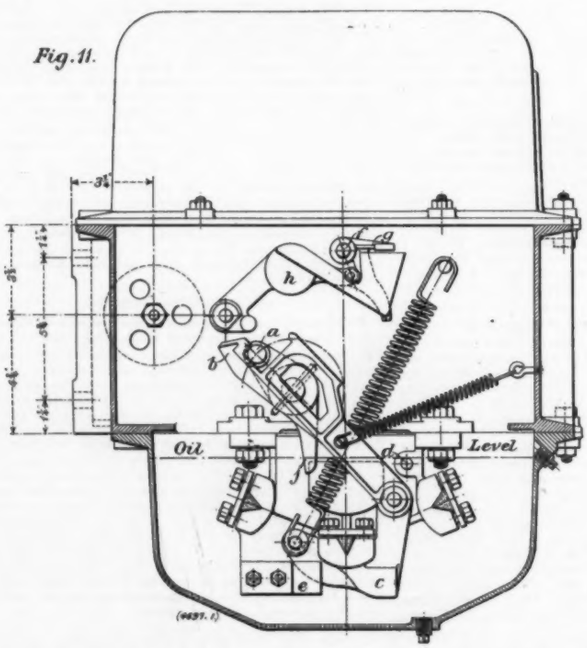
ELECTRICAL SWITCH-GEAR FOR INDUSTRIAL PURPOSES.

CONSTRUCTED BY THE ELECTRICAL APPARATUS COMPANY, LIMITED, ENGINEERS, LONDON.

(*For Description, see Page 552.*)







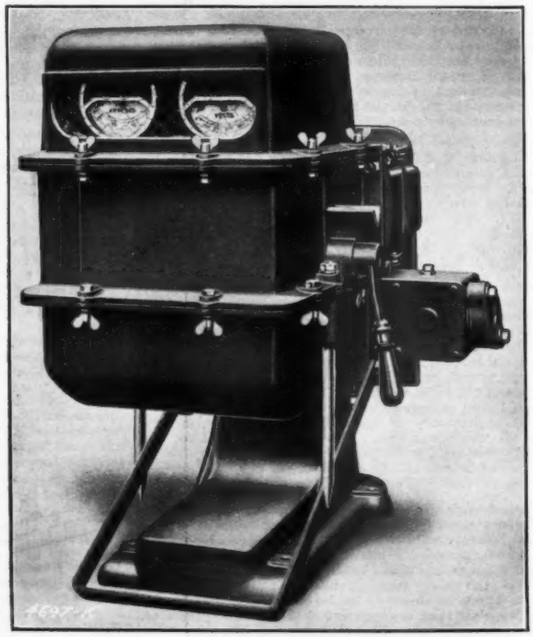


FIG. 12.

IRON ORES.—During the first half of 1915 the demand for iron ore in the United States was light and the production was only small; in the second half of the year, however, there was a great increase of activity, and it was a question not so much how much ore producers could sell, but how much they could deliver. Last year witnessed shipments (139,110 tons) from Tofo, Chile, through the Panama Canal to the Bethlehem Steel Company, which has purchased extensive iron mines in that quarter. The Bethlehem Steel Company also imported last year, under a 10 years' contract, 207,329 tons from Sweden and 215,032 tons from Cuba. The Spanish-American Iron Company, which carries on the Cuban iron-mining operations of the Pennsylvania Steel Company, shipped last year 546,112 tons of ore from Cuba, and the Ponupo Manganese Company further shipped 65,930 tons from the same quarter. Altogether it is estimated that 1,300,000 tons of iron ore were imported into the United States in 1915.

ALLOYS USED IN ZEPPELIN CONSTRUCTION.—Our New York contemporary the *Iron Age* reproduces the following figures from the French publication *Revue des Produits Chimiques* for the analysis of the alloys entering into the construction of a Zeppelin brought down in France :—

	Angle Brackets.	Channel Sections.	Braces.
	Per Cent.	Per Cent.	Per Cent.
Aluminium	90.27	88.68	99.07
Zinc	7.80	9.10	0.13
Iron	0.45	0.43	0.38
Silicon	0.37	0.49	0.36
Copper	0.73	0.70	0.06
Tin	0.11	0.15	...
Manganese	0.27	0.45	...
Nickel	Trace	Trace	Trace

The braces are evidently commercial aluminium, whilst the other parts are alloys of aluminium, zinc, copper and manganese. The absence of magnesium is noticeable.

THE LATE PROFESSOR HARRY C. JONES.—Professor H. C. Jones, of Johns Hopkins' University, Maryland, who died a few weeks ago, was an enthusiastic worker in the field of electrolytic dissociation, into which his studies under Ostwald, Van 't Hoff and Arrhenius initiated him. He was born in New London, Maryland, in 1865, and studied for two years in Europe after having been to the famous State University at Baltimore, which later on appointed him professor of physical chemistry. For twenty years he published, in conjunction with his students, a long series of over a hundred systematic papers on conductivity, freezing-point determinations, viscosity and other matters intimately connected with solution and ionisation. He had his own "solvate theory of solution," which he investigated also spectroscopically. Though he certainly did not escape criticism, he was justly popular everywhere. His best-known books are the "New Era in Chemistry" and "Elements of Physical Chemistry."

LIFT-LOCKS AT PETERBOROUGH, ON THE TR

DESIGNED AND CONSTRUCTED BY THE DOMINION BRIDGE COMPANY

(For Description see Page 5

Fig. 8. GENERAL PLAN

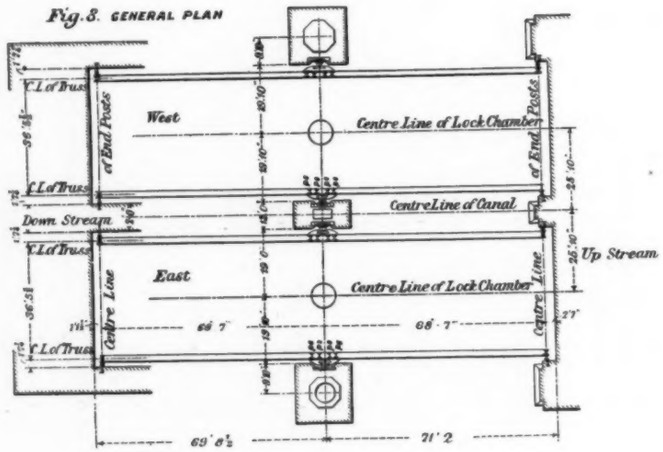


Fig. 4.

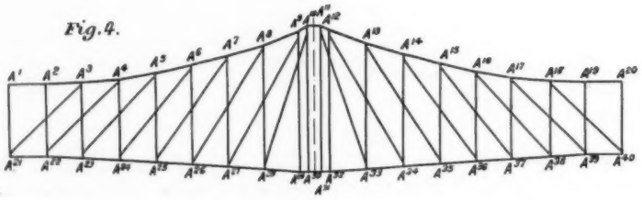


Fig. 9

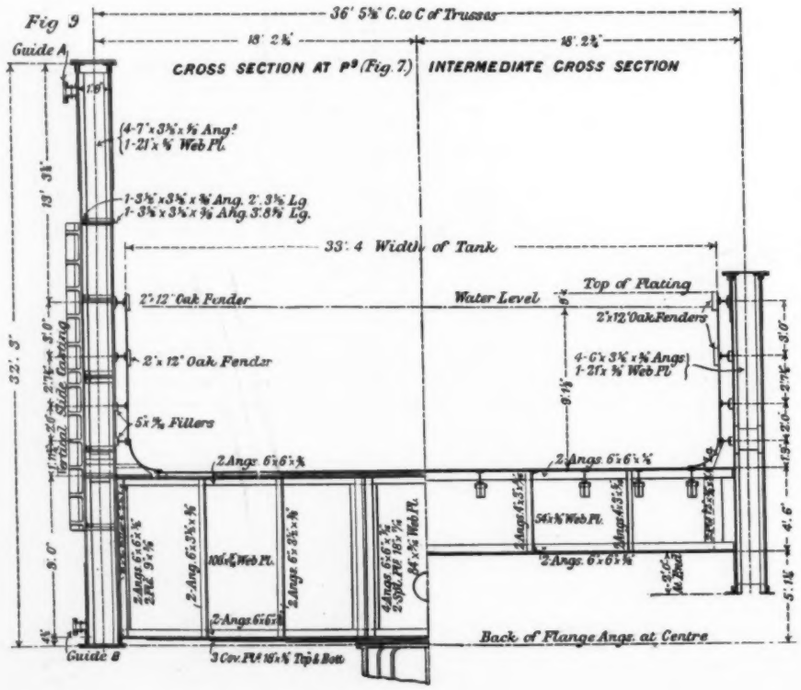

36' 5⅝" C. to C of Trusses
18' 2⅞"
18' 2⅞"
Guide A
CROSS SECTION AT P² (Fig. 7.)
INTERMEDIATE CROSS SECTION
(4-7" x 3½" x ⅝ Angs
1-21" x ⅝ Web Pl.
1-3½" x 3½" x ⅝ Ang. 2' 3½" Lg
1-3½" x 3½" x ⅝ Ang. 3' 8½" Lg.
33' 4 Width of Tank
2"x12" Oak Fender
Water Level
Top of Plating
2"x12" Oak Fenders
2"x12" Oak Fender
4-6" x 3½" x ⅝ Angs
1-21" x ⅝ Web Pl.
5" x ⅞ Fillers
2 Angs 6" x 6" x ⅞
2 Angs 6" x 6" x ⅞
54" x ⅝ Web Pl.
2 Angs 6" x 6" x ⅞
Back of Flange Angs. at Centre
Guide B
3 Cov. Pls 18" x ⅝ Top & Bott

Fig. 5. INSIDE VIEW DOWN STREAM

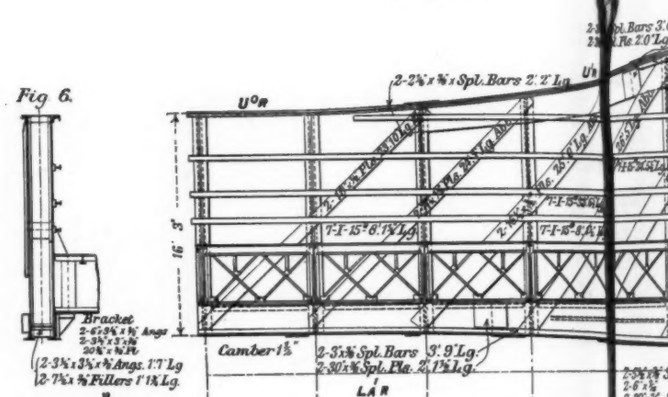

U⁰R
2-2¾" x ⅝" x Spl. Bars 2' 2" Lg
16' 3"
Bracket
2-6" x ¾" Angs
2-3½" x 3" x ⅝
30⅛" x ⅝ Pl.
2-3½" x 3½" x ⅝ Angs. 1' 7" Lg
2-7⅞" x ⅝ Fillers 1' 1" Lg.
Camber 1½"
2-3" x ⅝ Spl. Bars 3' 9" Lg.
2-30" x ⅝ Spl. Pls. 2' 1½" Lg.
L¹R
L²R

Fig 6.

Fig. 10.

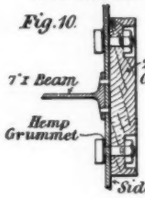


Fig. 7.

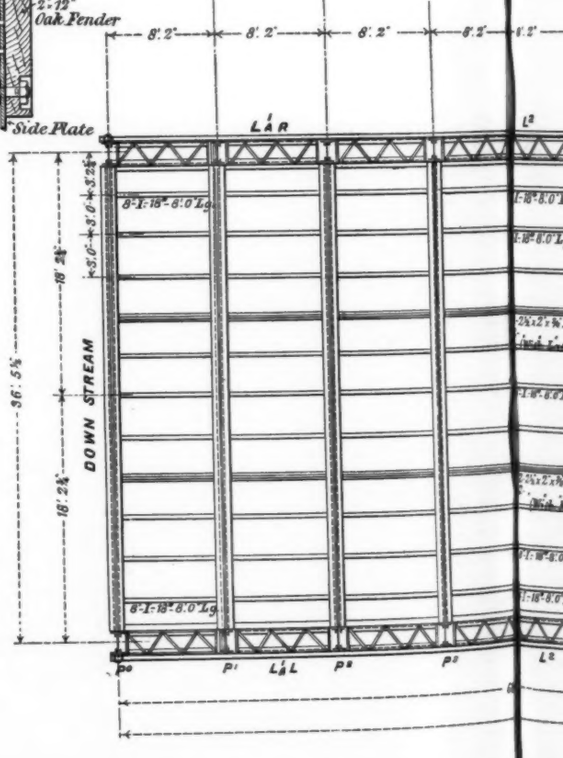
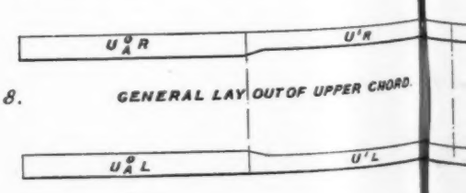


Fig. 8. GENERAL LAY OUT OF UPPER CHORD.



TE TRENT CANAL, ONTARIO, CANADA.

BRI COMPANY, LIMITED, ENGINEERS, MONTREAL, CANADA.

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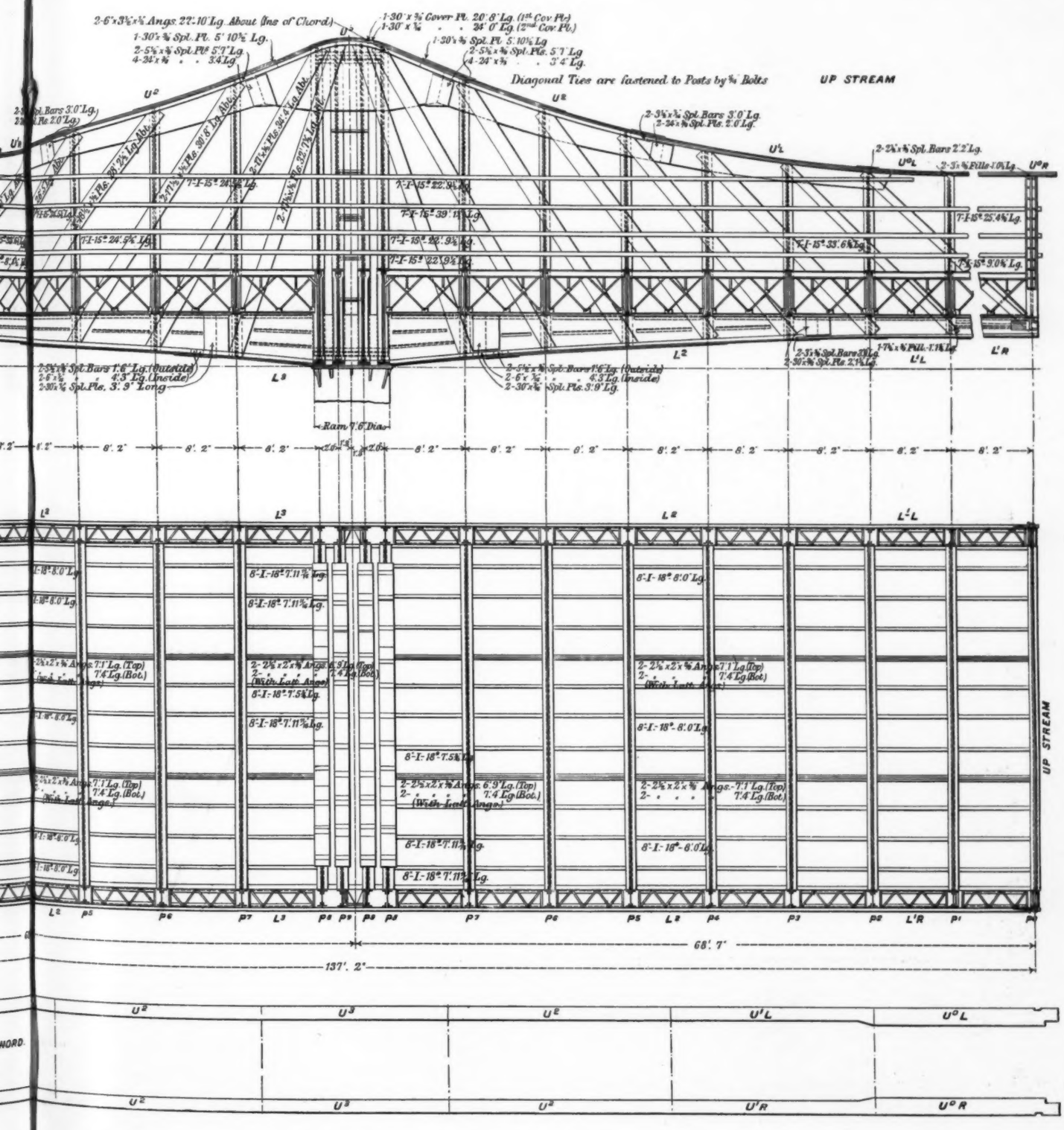

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"ENGINEERING" may be ordered from any Newsagent in town or country and at railway book-stalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months, payable in advance:—

For the United Kingdom	£1	15	6

The increase in the annual subscription is entirely due to the new postage rates on newspapers.

For Canada—			
Thin paper copies	£1	11	6 ($7.65)
Thick "	£1	16	0 ($8.75)
For all other places abroad—			
Thin paper copies	£1	16	0
Thick "	£2	0	6

When foreign subscriptions are sent by Post-Office Orders, advice should be sent to the Publisher.

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Offices for Publication and Advertisements, 35 and 36, Bedford-street, Strand, London, W.C.

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TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.
TELEPHONE NUMBERS—3663 and 8598 GERRARD.

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With a Two-Page Plate of the LIFT-LOCKS AT PETERBOROUGH, ON THE TRENT CANAL, ONTARIO, CANADA.

NOTICES OF MEETINGS.

THE MINING INSTITUTE OF SCOTLAND.—Saturday, June 10, at 3 p.m., a general meeting will be held in the Heriot Watt College, Chambers-street, Edinburgh. Mr. Henry Briggs's paper on "A Device for the Rapid Estimation of Oxygen and Black-Damp in Mines" will be discussed. Mr. James Nisbet's paper on "The Sinking and Equipment of a Circular Shaft" will be discussed. Mr. David Ferguson will read a paper on "The Hurlet Sequence and the Base of the Carboniferous Limestone Series in the Districts of Campsie and Kilsyth." The paper will be illustrated by lantern-slides and photographs.

THE PHYSICAL SOCIETY OF LONDON.—Friday, June 16, at 5 p.m., at the Imperial College of Science, Imperial Institute-road, South Kensington, S.W. Agenda:—1. "A Method of Measuring the Pressure of Light by Means of Thin Metal Foil," Part II., by Mr. Gilbert D. West, B.Sc. 2. "The Viscosity of Suspensions of Rigid Particles at Different Rates of Shear," by Edith Humphrey, B.Sc., Ph.D., and E. Hatschek. 3. "Experiments with Mercury Jet-Interrupters," by Captain C. E. S. Phillips, F.R.S.E. 4. "A Correction of Some Work on Diffusion, by Dr. A. Griffiths and Others," by Mr. A. Griffiths, D.Sc.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

ENGINEERING.

FRIDAY, JUNE 9, 1916.

REFLECTIONS ON THE GREAT SEA BATTLE.

THE one definite deduction which can be made from the facts regarding the great naval battle off the coast of Jutland on Wednesday of last week is that all is well with the Navy. We know now the full strength of the enemy on the sea—the mental calibre of the strategist and tactician, the degree of accuracy in gun fire and torpedo fire, and the power and extent of the *matériel* of his fleet. In none of these respects has there been disclosed any capacity which could, by any stretch of the imagination, justify the suggestions that Germany had surprises in store for us. We were told by pessimists that Germany was probably, by her credited initiative and ingenuity, evolving for the Naval Service hideous instruments of warfare corresponding to those used on land in direct contravention not only of the Articles of the Hague Convention, but of the laws of humanity. On May 31 the German fleet, with all its strength, came out from behind their mine-locked secure position, did their worst, or their best, and were compelled to retreat to their base, demoralised, seriously crippled by loss and damage, and scattering mines behind them in order again to make their hiding place reasonably secure against attack.

In the absence of a full and accurate narrative of the engagements it is impossible to draw any but a general conclusion as to the relative superiority of the *personnel* or *matériel* of the opposing fleets. Nor do we propose here to attempt to reconstruct the course of events from the insufficient data available. It would seem as if, for the first time, battle-cruisers took their place in the line of battle against ships of the line, a procedure which was considered by some as practicable, and by others only as a last resort. Obviously Admiral Beatty, with characteristic English pluck, determined to take the risk in order to keep the German High Sea Fleet from returning to its base before Admiral Jellicoe's Grand Fleet had had an opportunity of engaging in action. It may also be true that because of their deficiency in armour, which in the battle-cruiser had in some degree to be sacrificed to increase the speed, our battle-cruisers suffered more than would otherwise have been the case. A consideration in preparing the design was a probable long range of battle, and the mist which justified Admiral Beatty in shortening the range gave the German ships of the line an advantage. Since, however, the assumption is tenable that the German ships concentrated their fire upon the Queen Mary, it is doubtful, under the circumstances, if any ship, however effectively armoured, could have continued afloat for a much greater period of time than the few minutes which sufficed to sink our premier battle-cruiser. The same applies in even greater degree to the other cruisers lost, which were not even so well armoured or armed as the Queen Mary. It results therefore that here, as in so many cases, circumstances will militate against any definite conclusion as to whether the battle-cruiser can be considered as alternatively useful for action in the line. Certainly the squadron of Admiral Beatty played a magnificent part, one consistent with good tactics, and with completely satisfactory results, as they secured to Admiral Jellicoe's Grand Fleet the opportunity of a "stand up" engagement, which only failing light and weather conditions prevented from being an even more decisive defeat of the German force than, under adverse circumstances, was the case.

The arrival of Admiral Jellicoe's Grand Fleet altered the whole phase of the battle. Here again the absence of information makes any definite analysis premature; but two facts stand out clear, and are in the highest degree reassuring. In the first place, independent narratives prove that the accuracy of fire of the British gunners was immensely superior to that of the Germans when there was greater need for that accuracy on the part of the enemy's *personnel*. The range was not long, but the engagement was continued with ships steaming at a remarkable speed. We believe that during the major part of the engagement the ships were steaming at about 20 knots, and as for much of the time the British line of battle, with ships at 3 cables apart, were silhouetted against the sunlit sky, while the Germans had the distant land behind them, the advantage was all in favour of the enemy; and yet during this part of the engagement little damage was done to any of our battleships—certainly none of them were rendered *hors de combat*. The speed from the time our ships left port on the long race to the venue of the battle, throughout the trying engagement, and later in the search for stray enemy ships, was a notable achievement. The work of the engineer on board was thus of vital advantage, but there was absent from it that evidence of achievement which falls to the lot of the tactician on the bridge or the man behind the gun. All his horizon is bounded practically by an engine-room telegraph, and his nerve is strained to respond instantly and fully to the calls made on it, while there cannot be absent from his mind the possibility of disaster, which, as in the case of the heroes in the Queen Mary, Invincible, and the other ships which so quickly sank, brought with it death, with all the agonies and without any immediate glory. Tribute should therefore be paid not only to the dead heroes, but to the men who went through the trials of the recent battle displaying such high efficiency. A word, too, is due to the designers and to the makers of that machinery, because in no single instance did any of our ships fail through wear and tear of machinery to return to their base, after an experience unequalled in the history of naval machinery.

Perhaps the most remarkable feature, and probably the most demonstrative of British victory, was the night engagement taken up by the small craft, the mosquitoes of the British Fleet, when it was realised that no good could result from the Grand Fleet following the German Navy through its mine-fields, and that the retreat of the enemy without accomplishing any object whatever maintained British sea supremacy. Torpedo-boat destroyers, and vessels of such type, continued the fight. No words are too superlative to characterise the splendid spirit which was displayed during this attack, and yet the losses on the British side were surprisingly small. There is no definite knowledge as to the enemy's losses; these are known only to "the high command" of the German fleet, and they are not the least likely to make disclosures which would sweep into obloquy the earlier assertions of a great triumph. The great fires due to explosions, witnessed by the officers and crews of our destroyers during the night, were enough of themselves to establish that destruction was overtaking many of the German ships, due to our torpedoes. The most convincing fact of all as to the morale of the German *personnel* is that most of the German ships were displaying their identification lights, in order to ensure that ships of their fleet would not ram or otherwise imperil their own vessels. Not a single

British ship indeed showed its lights, nor did they use searchlights, so that the identification lights and searchlights of the enemy were most helpful in the discovery of targets for our destroyer torpedoes.

We do not propose to enter into any arithmetical calculation as to the losses in both fleets. That the balance positively is against Germany, time and the disclosure of the truth will establish clearly. Even equality in loss—that is to say, ship for ship—would be relatively a great gain for the British Navy so far as future actions are concerned; because if 10 ships are destroyed in a fleet containing 100, and an equal number in a fleet containing 60, the result is to leave 90 ships opposed to 50, instead of 100 as opposed to 60. A repetition several times of the process would soon bring the smaller fleet to extinction. The task, however, of the British Navy will continue to demand a great superiority in units, because the object of the German fleet was probably to enable a great squadron of commerce raiders to get to sea. To render such impossible must continue to be the work of our Fleet, and at the same time to continue the blockade, which is a sure way to make the German nation realise that their defeat is certain. Consequently it is imperative that we should lose no moment of time in maintaining our Fleet at the maximum standard desired by the naval authorities. Ships are bound to be lost in any action if the power of the British Navy is to be thrust home to the fullest extent. To take the place of those ships, as well as to increase the margin of safety demanded by the very wide extent of guardianship exercised by the Fleet, every worker, whether in the shipyard, in the turbine shop, in the boiler works, in the gun factory, in the gun-mounting department, or in the projectile and ammunition factories, must not only give his fullest possible time, but the best of his effort. The one great lesson of the battle to the nation is that if the lives of our heroes afloat and in the trenches are not to be given in vain, the men and women in the factories must do their part unceasingly and ungrudgingly, in order that whatever momentary advantage the enemy may gain by the destruction of material or the maiming of our sailors and soldiers, victory will be established by that oneness of will and oneness of manufacturing power which the British Empire can and must now exercise.

FUSIBLE TIN BOILER-PLUGS.

IN May, 1914, a boiler of the American steamship Jefferson exploded, killing several people. The explosion was ascribed to low water. This deficiency should have been indicated by the melting of the boiler-plug, which was found unmelted and apparently sound. Since 1852 all marine boilers of the United States merchant service—excepting pipe, flash, and coil boilers—have been under the supervision of the Steamboat Inspection Service, which insists upon the installation of fusible boiler-plugs consisting of a brass or bronze casing entirely filled with pure tin. The United States Navy does not use boiler-plugs, on the ground that they might foster negligence; some railroad engineers share this opinion, but the plugs are in use in factories and locomotive boilers.

The Jefferson accident was investigated by the Bureau of Standards. The plug was sawn open longitudinally, and it was found that there was little of the original tin left; most of the metal was embedded in a dirty, greenish-white matrix of tin oxide, which had a melting-point above 1600 deg. Cent.—*i.e.*, a higher melting-point than the bronze casing and the boiler steel probably—whilst pure tin melts at 232 deg. Cent. The results of the investigation are given in Technologic Paper No. 53 of the Bureau of Standards, by Messrs. G. R. Burrell and P. D. Merica. The investigation concerned 950 new plugs and 100 plugs which had been in service, the plugs being supplied by 105 firms. Ninety-seven of the plugs were not in accordance with specifications, 10 showed blow-holes. Of the old plugs, 22 had remained unchanged in 12 months' service; 47 had partly melted at the fire end, but were otherwise sound; in 11 cases the filling had swelled and protruded at the fire end or at both ends, there being an oxide deposit between the tin and the casing in some cases. Oxidation of the plug material itself was observed in 14 cases, the oxide sometimes taking up nearly half of the plug length from the fire end; two plugs had partly been blown out, the inrush of cold water having apparently stopped the process. Only seven plugs had the "network" appearance of the Jefferson plug, or were pressed in at the water end. These plugs all contained zinc and had low melting-points. The latter were determined in two ways: by taking cooling curves, and by placing a small sample of the specimen and a sample of pure tin on a strip of platinum which was slowly heated by the electric current. It was observed that the presence of zinc and lead and most other metals lowered the melting-point of tin—to 225 deg. Cent. in the worst case—whilst iron and antimony raised it; the latter point was established by adding the respective metal to pure tin.

That the most common impurities of tin, *i.e.*, zinc and lead, are responsible for the deterioration was proved by special experiments. Plugs of pure and impure tin (containing up to 10 per cent. of zinc and 5 per cent. of lead) were prepared, oxidation being either prevented or purposely favoured; it was found that the presence of even 25 per cent. of tin oxide in the tin hardly affected the appearance of the plug. The plugs were put in an autoclave, filled with tap-water or distilled water, and kept at 180 to 195 deg. Cent. or more for 50 hours. According to Guertler, tin takes up very little zinc (0.12 per cent.) in solid solution, but alloys with zinc in all proportions, giving crystallites of zinc in the tin matrix; at 197 deg. Cent. the crystals coalesce under prolonged heating, and the tin crystals are then found to be surrounded by an envelope of zinc. Water, especially if superheated and alkaline owing to softening, attacks tin, particularly impure tin, corroding the zinc and honeycombing the structure; when the crystals coalesce as indicated, the whole plug may yield to the water or steam pressure and be forced out in the direction of the fire end; this was observed in the case of one plug. That the corrosion had started from the water end was plainly visible; the water side was always badly corroded when the network oxidation had taken place. But some of the impure tin plugs were found uncorroded, and it would appear that these plugs also contained lead. Thus, while the presence of either zinc or lead is undesirable, a little lead seems to be able to counteract the evil effects of zinc. One plug contained 1.8 per cent. of zinc and 0.1 of lead, and was sound after three months' service. It is suggested that the progress of the network oxidation depends upon the previous presence of the coalesced network zinc-tin structure; and if for some reason the zinc be present in some other form of distribution, the oxidation cannot proceed in the dangerous manner. The fine photographs of the microstructure bring these features out very well, and it is significant that the five plugs, which had developed network corrosion in service, did not contain lead, and were all from the same manufacturer. Yet we do not think that the action of lead is quite cleared up.

Attention is drawn to one further point. The coefficient of expansion (per deg. Cent.) of brass is about 0.00020, of tin 0.00023. Tin, moreover, undergoes an allotropic change at 160 deg. Cent., and alloys rich in zinc may develop cracks. The plugs are thus likely to become leaky, and a number of service plugs had indeed been removed for this reason. In other cases the leaks had been stopped by plaster-of-Paris and other means which further introduced sulphates and other impurities. The remedy of the whole trouble would be to use only the purest tin as plug material, and the new rules of the Steamboat Inspection Service (of December, 1914) demand a tin of 99.7 per cent., whilst the old rules did not specify any purity, and up to 4 per cent. of zinc had actually been found in the examined plugs. The best Banka tin is at present difficult to obtain; but the paper points out that tin from Pyrmont (Australia), the Straits Settlements, and from some works is almost equally pure. It is further proposed to entrust the manufacture of fusible tin plugs to a few especially licensed firms. To abolish the plugs, or at least their obligatory installation, does not appear to be demanded.

X-RAYS AND THE THEORY OF RADIATION.

CONSIDERING that the theory of radiation has been the foremost fundamental problem of late years, while X-rays are becoming more and more a general weapon of experimental research, it may appear a little surprising that Professor C. G. Barkla, F.R.S., of Edinburgh, in introducing his Bakerian Lecture on "X-Rays and the Theory of Radiation,"* should have remarked that discussions on the electro-magnetic theory of radiation did not give full consideration to X-rays. Many scientists at present incline to a certain modification of the theory. Professor Barkla, to whom science owes the remarkable discovery of characteristic X-rays, rejects the suggestion of a modification; he does not believe that radiation energy is emitted and absorbed in definite, indivisible quanta; to him the phenomena become meaningless on the suggestion of a quantum or entity of radiation. Professor Barkla is, however, prepared to accept the quantum theory in a sense, rather as one of atomic energy than as a quantum theory of radiation. We will attempt to give a brief summary of his views as expounded in the Bakerian lecture and also in the Royal Institution discourse of last Friday week. Broadly speaking, the problems of radiation are problems of electrons and atoms. Negatively charged corpuscles (electrons), Professor Barkla pointed out, were emitted by matter when exposed to heat, cathode-ray bombardment and other conditions; but there was an analogous emission of positive particles under the same conditions, except with radioactive substances whose positive particles were atoms of helium. The electrons were studied by their magnetic deflection and by the ionisation which was directly produced by them and indirectly by the X-rays. The energy of X-rays of differing wave-lengths might be compared by measuring the total ionising power. In his Bakerian lecture Professor Barkla considered the X-ray emission under three heads: as scattered X-radiation, as fluorescent (characteristic) X-radiation, and as primary X-radiation. We should almost prefer to begin with the last of the three; but as there was little time left in the lecture for the third head, we will follow Professor Barkla's sequence.

Scattering, he said, was the process of re-emission of secondary radiation by matter, on which primary radiation fell. Experiments on the quality, polarisation and distribution of the scattered radiation showed that it was emitted by electrons whose motion—that part which resulted in radiation—was completely controlled by the primary radiation; long-wave primary rays gave long-wave secondary waves, &c. The intensity of the scattered radiation was greatest in the direction (both forward and backward) of the ray, and depended simply upon the mass of the atom, not upon the primary wave-length, while the number of electrons in an atom was simply a function of the atomic weight. According to Sir J. J. Thomson, the intensity of scattering in air was given by the formula $\frac{8\pi}{3} \cdot N e^4/m^2$, where N was the number of electrons, e their charge, and m the mass. The number of molecules contained in a cub. cm. of air was 2.75×10^{19}, and in his (the lecturer's) early calculations the number of electrons had come out hundreds of times greater than that product. Very careful later measurements proved, however, that the number of electrons was always equal to half the atomic weight, so that the carbon atom contained 6, the nitrogen atom 7, the oxygen atom 8 electrons, and so on; hydrogen (atomic weight 1) was an exception to the rule, for it had one electron per atom. J. J. Thomson had suggested that the electrons were distributed in a uniform field of positive electricity. From the scattering of α particles Rutherford had concluded that the positive electricity must be concentrated in a small central nucleus, about which the electrons revolved in rings; and Bohr and Moseley had extended this view in order to account for the lines of the spectrum, the hydrogen lines of the Balmer series in the first instance. In order to explain all the properties of hydrogen by the assumption of one electron

* Delivered at the Royal Society on Thursday, May 25.

revolving about the nucleus, Bohr had suggested that the hydrogen atoms differed from one another as to the orbits of their electrons; if the radius of one hydrogen atom (distance of the electron from the nucleus) was 1, it would be 4, 9, &c., for others. Professor Barkla could not understand that. In his opinion, X-rays travelling over matter disturbed every electron, and X-rays produced in the lecture theatre would, for instance, cause every electron in the bodies of his audience to tremble. Groups of atoms, and even of atoms—not merely individual electrons—were concerned in X-radiation, and the whole deduction strongly supported the adequacy of an unmodified theory of electro-magnetic radiation by transverse rays.

These arguments were strengthened by the consideration of the fluorescent (characteristic) X-radiation, which could only be excited by a radiation of shorter wave-lengths—*i.e.*, of higher frequency than the fluorescent radiation which was characteristic for each element. The intensity of these characteristic rays was uniform in all directions (the curve being a circle, not a kind of ellipse, as with scattered rays); there was no polarisation, and the characteristic rays were not controlled by the primary; in fact, they arose only indirectly from the primary beam, and its emission was only an accompaniment of an exceptional disturbance, which was probably of the nature of the ejection of a high-speed electron. The intensity was independent of the speed of ejection and of the career of the electron after its ejection; the radiation did not arise outside the parent atom, and the origin of the radiation was really in the atom. The further study of the relation between the fluorescent radiation, the corpuscular radiation, and the special absorption of the primary beam threw light on the process. An element might give rise to several characteristic radiations distinguished as belonging to the K and L series, the K being of higher frequency and harder than the L. Recent studies of carbon, nitrogen, aluminium and sulphur suggested the further existence of a still harder series, J, and possibly also of softer series, M, N, &c. When E was the total energy absorbed, S the energy of the primary re-emitted as scattered radiation, and E_K, E_L, &c., were the energies absorbed in association with the emission of the respective characteristic rays, then $E = S + E_M + E_L + E_K + E_J$. The total corpuscular radiations of energy C could similarly be divided into groups: $C = C_M + C_L + C_K + C_J$. While the general absorption experiments had chiefly been made on metals, the K radiation had particularly been measured in the case of bromine, and it resulted that it required more primary energy to expel a K electron than an L electron, and that a quantum of K radiation was probably the energy required to move an electron from the K position to the L position, and that further one quantum of K characteristic radiation was emitted for each K electron ejected.

The atom of Professor Barkla would thus consist of a central nucleus of positive electricity surrounded by concentric rings of electrons of the J, K, L, M types; the K electrons, being nearer the centre, would require more energy for expulsion than the L electrons; but they would all be ejected from the atom at the same velocity. A displaced K electron would leave a gap, into which an L electron (possibly also an M) might drop, the energy previously absorbed in displacing the K electron being re-emitted as a quantum of K radiation. When the primary wave-length μ_1 was just less than its characteristic wave-length μ_2, the energy was almost equally divided between the characteristic E and the corpuscular radiation C. As μ_1 decreased, the C energy increased, and for very short μ_1 nearly all the energy would be taken up by the corpuscular radiation. In the case of bromine the division was not quite equal, the fluorescent radiation making up only 0.47 (instead of 0.5) of the total; for elements of higher atomic weight the value 0.5 was nearly attained.

Finally, Professor Barkla stated that as the generation of a radiation of a given frequency by cathode rays necessitated the incidence of electrons with energy greater than that of a quantum of that radiation (even for the production of radiation not recognisable as characteristic of the respective anti-cathode); it seemed probable that the process of X-ray generation was itself one of the same character as that resulting in the emission of characteristic X-rays, and that mere collision should produce X-rays was doubtful. Though X-radiation might be and was emitted by electrons (probably by groups of electrons or even atoms) as a continuous process and in any quantity whatever, also in fractions of a Planck quantum, it was emitted in quanta from atoms when certain critical conditions were reached. In this sense Professor Barkla spoke of a quantum theory of atomic energy rather than of a quantum theory of radiation. The full consequences of his theory had not been worked out yet; some of his conclusions had been confirmed by W. Kossel; some might require modification.

In commenting upon this very important contribution to fundamental research, Sir J. J. Thomson, President of the Royal Society, remarked that he agreed that the emission of an electron carried by a unit of X-ray radiation was, so to say, the death of that unit. But he did not go so far as Professor Barkla in putting the corpuscular radiation—in the old sense—altogether out of court. Referring to his recent Royal Institution lecture on radiation, he drew attention to the way in which, he thought, the orthodox theory of light and the quantum theory could be brought into harmony.

EARL KITCHENER.

ORDINARILY, the death of a military man, however eminent, does not call for notice in our columns; but Lord Kitchener, whose tragic end last Tuesday sent a thrill through the world, had so many points of contact with engineering matters that we cannot let the occasion pass without some reference to it. The fact that in the early part of his life he held a commission in the Royal Engineers would not be sufficient warrant for us to refer to his career, for military and civil engineering are separated by a wide gulf, and we make no pretensions to deal with both sides of it. The point that attracts us is that Lord Kitchener applied to warfare the methods which engineers employ in their great enterprises. He recognised that the destruction of an enemy's forces is one of the "uses and conveniences of man" for which we have to guide and control the forces of Nature, and he made use of all the means that engineering science affords for the purpose. Further, he laid his plans with the minute care we are accustomed to see lavished on a great civil engineering work, and when he had completed his preparations in the way of transport, *matériel* and commissariat, the military successes followed so easily and regularly that they seemed as simple as letting the water into a new dock or launching a vessel into a river. Of course, we are not speaking of the present struggle, for no one can suggest that the period of preparation is yet over, or that any single mind could compass the vast complexity of problems that present themselves from day to day; but the lines laid down by Lord Kitchener, if followed to their legitimate conclusion, will ensure victory. That is an abiding faith with the Empire and the Allies.

In all the previous phases of his career after Kitchener had risen to a position which gave him a free hand we see displayed the qualities which make a great engineer or a great contractor. He reckoned up the forces against him, not only the thousands of the enemy, but the miles and miles of sand, the distances between the wells, the rapids in the rivers, the insalubrity of the climate, and then set himself to conquer Nature as far as it could be done. He called to his aid the locomotive and the steel rail, the steamboat, the well-sinking equipment, and by these means he moved his men with the minimum of fatigue and saved them from unnecessary hardships. All his stores were brought up within striking distance of the enemy, and the actual campaign was narrowed to a few miles and days. This was done not once, but several times in Egypt, for the conquest of the Soudan was an affair of stages. In one respect only did Kitchener show a remarkable divergence from the usual practice of the engineer, for, according to a statement by Lord Salisbury, he made his great advance to Khartoum for considerably less expenditure than set forth in the estimates which had been accepted by the British Government. The total cost of the campaigns of 1896–98 was only £E.2,354,000, of which £E.1,355,000 was spent on railways and gunboats. We disburse twice that amount each day now. Moreover, his work in the Soudan proved of great material advantage in the subsequent peaceful development of the country. He had taken the far-seeing decision to span the desert from Wady Halfa, a distance of 230 miles, with a well-built railway to facilitate the transport of his army. Its construction within a surprisingly short time, like the conception of this method of transport, was thoroughly characteristic of that completeness which marked all his preparations. At the same time his motto was *Festina lente* Thus he rarely erred: nothing was found wanting at the critical moment.

South Africa did not present a favourable field for Lord Kitchener's methods. The country was too vast and the enemy too scattered to render any system of concentration useful. Finally, however, the hundreds of blockhouses, and the miles upon miles of barbed-wire fencing so narrowed the field available to the Boers that they accepted the very liberal terms offered to them and laid down their arms.

From South Africa Kitchener, now Viscount Kitchener, went to India as Commander-in-Chief, and he spent the greater part of the seven years he passed there in improving the material organisation of the Army. He found that its contentment had not been ensured by adequate provision for its well-being, and that its safety had not been provided for by making it self-supporting in regard to munitions. He rearranged the stations to enable them to take full advantage of the railway system for rapid mobilisation both towards the frontier and towards the interior of the country. He improved the medical service to combat disease and prevent suffering, he established grass and dairy farms all over India, and he built factories to render the Army self-supporting in materials of war. Regarding the military forces of the country as a machine, he sought for every element of bad design and every source of friction and inefficiency, and did his best to remove them. He did corresponding service in the organisation of the forces of Australia.

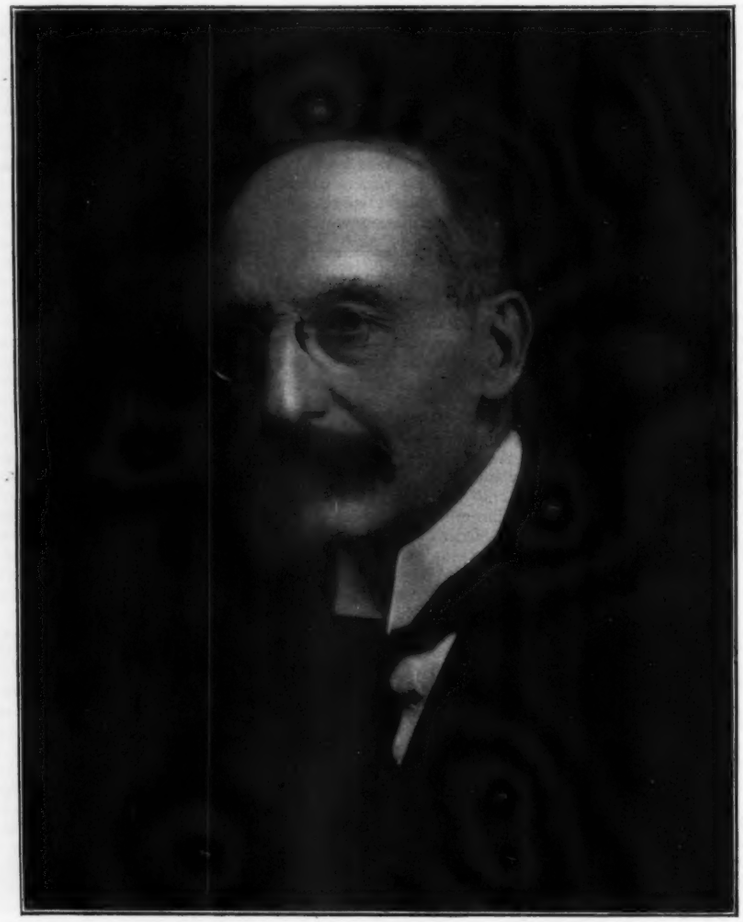
In his last great appointment before the commencement of the present war—that is, as the representative of the British Government in Egypt—Lord Kitchener based his plans for the political improvement of the country on an increase in the material prosperity of the fellaheen, and he realised clearly how deeply that was connected with the continuance of the great irrigation and drainage schemes which had been in hand ever since our control of the country commenced. Gigantic works were commenced in the Delta, which was suffering from too much irrigation and too little drainage, while the works in the Valley of the Nile were brought into the highest state of efficiency. At the same time he showed that in spite of his somewhat austere demeanour, and of his predilections for organisation and machinery, he understood that mankind must also be tackled on the human side if it is to be rendered content. To this end he introduced reforms which saved the fellaheen from the rapacity of the native money-lenders and secured them from distraint in their small holdings, while at the same time he cheapened justice and rendered it as pure as is possible in an Oriental state.

Lord Kitchener's tragic end, during the most sanguinary of wars, was a side issue. He had undertaken a visit to Russia, to advise on matters connected with the war. He embarked on H.M.S. Hampshire, which sank off the Orkney Islands owing to mine or torpedo, and all on board were lost. In the small staff Lord Kitchener took with him from London last Sunday evening there were two mechanical engineers of eminence—Sir Frederick Donaldson, K.C.B., M.Inst.C.E., and Past President I.Mech.E.; and Mr. Leslie Robertson, M.Inst.C.E. and M.I.Mech.E., of whom obituary notices are published overleaf. Lord Kitchener was obviously contemplating making full use of the engineering science to which he had turned in all the great enterprises of his career, and which had so fully repaid the confidence he had placed in it.

THE LATE SIR H. FREDERICK DONALDSON, K.C.B.

IT is with very deep regret we record the death on Monday last, due to the sinking of H.M.S. Hampshire, of Sir H. Frederick Donaldson, who at the time was on his way to Russia as a member of the Staff of Lord Kitchener, representing the Ministry of Munitions. Of the tragic event itself we have spoken elsewhere, and it is our object now to deal with Sir Frederick's career.

Sir Hay Frederick Donaldson was the second son of Sir Stuart Alexander Donaldson, the first Premier of New South Wales, and was born at Sydney on July 7, 1856. He was educated at Eton and at Trinity College, Cambridge, afterwards receiving technical training at Edinburgh University. From 1875 to 1877 he served a term of pupilage and apprenticeship at the London and North Western Railway Works at Crewe, under the late Mr. F. W. Webb, and afterwards received further technical training, from 1877 to 1879, at Zürich Technical School and at Cambridge. In 1880 he was employed on Parliamentary work and as engineer in charge of the construction of the Burnley tramways under Mr. Joseph Kincaid, being later—in September, 1881 — appointed one of the assistant engineers, and shortly after made an executive engineer on the West of India Portuguese Railway and Harbour, under Mr. E. E. Sawyer. During part of his service with this company he was in charge of the harbour works at Goa, but he was mainly responsible for the construction of sections of the railway, involving much heavy work.



From a Photograph by Elliott and Fry.

H. F. Donaldson

In 1887, on the completion of his duties in India, Mr. Donaldson, as he then was, returned to England, and in the autumn of the same year was appointed by the late Mr. Thomas A. Walker to the position of engineer in charge of No. 1 section of the Manchester Ship Canal, this engagement involving the carrying out of the construction of entrance locks, estuary banks, and heavy piling work of great magnitude and importance.

After leaving the Manchester Ship Canal he was engaged in 1891 and 1892 in private engineering practice, and on January 1, 1893, he was appointed Engineer-in-Chief to the London and India Docks Joint Committee, a position which he held until December 31, 1897, when he received the appointment of Deputy Director-General of Ordnance Factories under the late Sir William Anderson.

Sir William Anderson died in 1898, and during the illness which preceded his decease, and after his death, Mr. Donaldson was temporarily in complete charge of the whole of the Ordnance Factories, and in 1899 he was appointed Chief Mechanical Engineer, in charge of all consultative business, the selection and purchase of machinery, and the modernisation of methods of manufacture. Later, in 1903, on the retirement of Sir E. Bainbridge, the object of our memoir was appointed Chief Superintendent of the Royal Ordnance Factories, a position which he held until his retirement last year.

Of Sir Frederick's excellent work at Woolwich the present is not the time to speak in any detail. It was work which involved vast responsibilities, and much of it was carried on under very trying conditions, due to labour troubles and other causes, which undoubtedly greatly taxed his health and strength. The present war, with the consequent unprecedented demands for guns and munitions of all kinds, necessitated great extensions of the factories and largely increased the work of control, and it was thus with no surprise that his friends learned last September that Sir Frederick had resigned the position which he had held with distinction for so many years. His services to the State were recognised in 1909 by the award of the honour of C.B., which was followed by K.C.B. in 1911.

On his retirement from Woolwich Sir Frederick was appointed Chief Technical Adviser to the Ministry of Munitions and he frequently accompanied the Minister of Munitions on his visits to the chief industrial centres throughout the country with the object of organising the British engineering and manufacturing resources for the production of war material of all kinds. It was, as we have already stated, as a representative of the Ministry of Munitions that Sir Frederick, in company with Mr. Leslie S. Robertson, became a member of the staff of Lord Kitchener on the visit to Russia, which resulted so fatally on Monday last.

Sir Frederick Donaldson took a most active interest in the affairs of the leading engineering institutions. He was elected an Associate Member of the Institution of Civil Engineers in 1882 and a full member in 1891, while at the time of his death he had been for a number of years a Member of Council. Of the Institution of Mechanical Engineers he became a member in 1898 and in 1903 he read a paper on "Cutting Angles for Metal Work." In 1906 he was elected a Member of Council, in 1911 he was made a Vice-President, and in 1913 and 1914 he held the office of President. During the first year of his Presidency the Institution held its summer meeting at Cambridge, the first time such a meeting had been held at a University town, and thanks to the admirable arrangements largely organised by the President and his late brother, Dr. S. A. Donaldson, then Master of Magdalen College, the gathering was a great success. In the succeeding year the summer meeting was held at Paris, and to the organisation of this meeting Sir Frederick also devoted much time and trouble,

but unfortunately the demands made upon him in connection with Woolwich Arsenal prevented him from being personally present at the meeting, Mr. Michael Longridge acting in his stead. The meeting was one of great interest, especially as it included visits to works and districts since devastated by the war.

In spite of the heavy demands upon his time, Sir Frederick was during his presidentship most energetic in his devotion to the work of the Institution, and he took a most active part in developing the system of examination for graduates and associate members which is now in force. He had also especially at heart the establishment on a sound financial basis of the Benevolent Fund of the Institution of Mechanical Engineers, and he made many most earnest and eloquent appeals to the members on its behalf. We sincerely hope that the memory of these appeals may continue to aid in the development of this most deserving organisation.

Sir Frederick also did excellent work in connection with the Engineering Standards Committee, both as a member of the main Committee and as Chairman of the sectional Committee on Screw Threads and Limit Gauges. In the work of this Committee he was especially interested, and in 1909 he delivered to the graduates of the Institution of Mechanical Engineers a highly instructive lecture on "The Interchangeability of Screw Threads," which was much appreciated.

Sir Frederick Donaldson had an exceptionally wide circle of friends, many of whom had been associated with him in various ways during his professional career and to whom he had been endeared by his thoroughly honourable and straightforward character. By all his colleagues he will be very deeply missed, and all will unite in sincere sympathy with Lady Donaldson and his son and daughters in their most sad bereavement.

THE LATE MR. LESLIE S. ROBERTSON.

THE lamentable disaster to H.M.S. Hampshire which resulted in the death of Lord Kitchener and Sir H. Frederick Donaldson, was unfortunately responsible for the loss of another well-known engineer, Mr. Leslie Stephen Robertson, who was also attached to Lord Kitchener's staff as a representative of the Ministry of Munitions. Mr. Robertson (the original family name "Robertson" was resumed in 1898), who was born at Kotagherry, India, on October 4, 1863, was the youngest son of Sir William Ross Robinson, K.C.S.I., sometime Governor of the Presidency of Madras, and of Julia, Lady Robinson, of 104, Inverness Terrace, W. He was educated in Germany and at King's College, London, and acquired his scientific training at University College, London, under Sir Alexander B. W. Kennedy (then Professor Kennedy), from 1883 to 1885. During his college career he carried out some original work on cast-iron beams, for which he was awarded a Miller Prize by the Institution of Civil Engineers. We may also mention here that Mr. Robertson was one of the organisers and the first Secretary of the University College Engineering Society.

On leaving college, Mr. Robertson served two years at the works of Messrs. Denny and Co., of Dumbarton, and subsequently, from 1887 to 1889, took a position in Messrs. Denny's drawing-office, being later appointed to superintend the Experimental Testing Department. He next had some experience at sea as engineer on board the R.M.S. Jumna, and in 1889 he entered the drawing-office of Messrs. John I. Thornycroft and Co., at Chiswick. Later he was appointed interim works manager until he was put in charge of a large contract for the French Government at the works of the Société Anonyme des Forges et Chantiers de la Mediterranée, at Havre. On the completion of this work he visited the United States and Cuba.

In 1892 Mr. Robertson commenced private practice as a consulting engineer in Westminster, and six years later he was joined by Mr. Frank D. Outram, late R.E., the firm being known as Robertson and Outram. Until 1898 Mr. Robertson was the representative of Messrs. Normand, the well-known engineers and shipbuilders at Havre, and had charge of all their work in this country. He also acted as secretary of the first section of the International Railway Congress held at the Imperial Institute, and accompanied the Commission on Light Railways appointed by the Cape Government.

Amongst other literary work, Mr. Robertson edited the English edition of the important treatise on "Marine Boilers," by M. L. E. Bertin, the well-known French naval constructor, and some 20 years ago he delivered a course of lectures on "Water-Tube Boilers" at University College, London. He also contributed various papers to the Institution of Mechanical Engineers and other technical societies.

During his practice as a consulting engineer Mr. Robertson designed and superintended the construction of various factories in this country and abroad, and in connection with the usual professional work of a consulting engineer, he visited Canada and the United States to report on various undertakings.

Mr. Robertson was elected a member of the Institution of Mechanical Engineers in 1892, and his contributions to that body include a paper

Photograph by Vandyke.

on "Canal Boat Propulsion," read in 1897, and one on "Narrow-Gauge Railways," read in 1898. He was elected an associate member of the Institution of Civil Engineers in 1889 and a full member in 1901. He was also a member of the Institution of Naval Architects, of the Iron and Steel Institute, and of several other public bodies. He was, further, chairman and director of several companies and was a Freeman (Pattenmakers) of the City of London.

In 1901 Mr. Robertson was appointed Secretary to the Engineering Standards Committee, and it is in connection with this important body which, under the chairmanship of Sir John Wolfe Barry, K.C.B., has done such admirable work, that Mr. Robertson is probably most widely known. The Engineering Standards Committee, with its broad and continuously extending range of work, and its numerous committees and sub-committees, constitutes a most complicated organisation, embracing very diverse interests and involving the co-operation of a very large number of eminent engineers and manufacturers. That this important body has, from the first, run quite smoothly and has executed its work in a thoroughly businesslike way is undoubtedly most largely due to the tact and powers of organisation displayed by Mr. Robertson, and we feel sure that this fact is fully recognised by all members of the various committees.

Last year Mr. Robertson—with the full assent of the Engineering Standards Committee—placed his services at the disposal of the Government in connection with the Ministry of Munitions and was appointed assistant to the Director of Production. It was in virtue of this appointment that he became a member of Lord Kitchener's staff and a victim of the tragic disaster of Monday last.

Mr. Robertson was a man of unbounded energy, and he possessed a personality which enabled him to carry out negotiations and smooth away difficulties with exceptional success. It is most sad that his career should have been cut short at a time when he was doing such admirable work, and when there was every reason to expect that he would have been able to continue that work and reap its rewards for very many years to come. His death creates a void which it will be very difficult to fill, and his loss will be deeply felt by all who have been associated with him for so many years past.

THE LATE MR. ELMER LAWRENCE CORTHELL.

THE crown and glory of a professional man's career is the esteem and recognition of his fellows, and there can be no prouder moment for him than when he is elected by his friends and his competitors to be the President of a Society representative of them all. At such a time one would anticipate that the Fates would at least give him a clear year to enjoy his well-deserved honour, but it is sad to have to announce that in the case of Mr. E. L. Corthell, the President of the American Society of Civil Engineers, less than half that period had elapsed before he succumbed, last month, to an insidious disease. His loss will not only be felt in America, but also in this and other countries, for in addition to being a great engineer, he was also a man of many activities, which reached far beyond his native land. Deeply engaged as Mr. Corthell was in many fields of engineering—in harbours, railroads, bridges, river training works, water works, and barge canals—he never allowed himself to be so much engrossed that he could not play a part in public policy. He aimed at making the influence of the engineer a factor in framing public opinion and in guiding those who ostensibly control affairs in the country. He was a prolific writer and an effective speaker, and in both capacities he never spared himself in advocating measures which he deemed important. His experiences in the Civil War in various grades, from private to captain, showed him what an important part the engineer played in warfare, even in those days, and he therefore exerted himself to found a civilian reserve corps of engineers, to act as a nucleus in case of national need. He succeeded in getting the American Institution of Consulting Engineers, of which he was twice President, to become a member of the Chamber of Commerce of the United States, so that it might bring its influence to bear directly on commercial affairs. Of the value of congresses he had a high opinion, and at many of them he played a very important part, both in the preliminary organisation and in the official proceedings. These gatherings were not confined to America, but included many in Europe.

In these and in many other ways Mr. Corthell endeavoured to raise the status of engineers by showing the world that they were competent to take a broad outlook, not merely to design and execute works, but also to decide what works were necessary and expedient, and what were not. He declined to be simply the agent of the capitalist, deeming it more fitting that capital should be controlled by the engineer. At the same time, once a project was entered upon, he never spared himself to bring it to a successful issue, in order that he might vindicate the accuracy of his advice and save his profession from the reproach of failure. Possessed of high ideals, and full of courage in advocating them, he was a natural, born leader, and in the course of his career he accomplished even more important ends than utilising the forces of Nature, for he set an example which has been stimulating to American engineers in general, and will help many of them to carry on the work he inaugurated so successfully.

It would lead us too far to attempt to detail all the great works Mr. Corthell was connected with in the period between the time he left the army and to-day. His first step was to go back to the Brown University, at which he had studied for two years

before the war called him, like most American youths, to the colours. He took the degrees of Bachelor and Master of Arts, and years later, in 1894, the University bestowed upon him the degree of Doctor of Science in recognition of his great engineering achievements. It is interesting to notice, however, how broad was the foundation on which he built his experience. He began in an engineering office in Providence, engaged in railroad, hydraulic, and municipal work. Thence he went to that splendid school of engineering experience, the Mississippi Valley, then being rapidly opened up after the war. Railroad and bridge work occupied him for a time, until he became associated with Mr. James B. Eads in the control of the river itself by the famous jetties at the mouth, and in the project, never carried out, of the Tehuantepec Ship Railway.

In 1887 Mr. Corthell entered into partnership with Mr. George S. Morison, the chief business of the firm lying in bridge work. In 1889 and 1890 he was Chief Engineer of the St. Louis Merchants Bridge over the Mississippi, and from this time he was constantly engaged in works of the greatest magnitude. One of the largest, and probably the one that interested him most, was the improvement of the harbour of Tampico, in Mexico, begun in 1889, for the Mexican Central Railroad. Before getting out the design, Mr. Corthell visited twenty-six European harbours, studying the various means adopted to produce a deep and permanent channel. He took the opportunity at the same time to examine the leading universities and technical schools in the countries he visited, to acquire information to be used in establishing the Chicago University School of Engineering and Architecture. His association with Argentina commenced in 1899, and lasted several years, during which period he advised on many schemes for improving the communications of the country. Since that connection was closed, Mr. Corthell has been consulted in regard to many engineering projects in his own land, but, as already explained, he has always found time to further any schemes which have offered the opportunity of demonstrating to the public the great debt they owe to engineers, or which promised to raise the status of the profession which he represented so ably. One of the latest objects to which he gave his attention was the proposal for the American Society of Civil Engineers to join the three other national engineering associations in the Engineering Societies' Building in New York. He was a member of very many engineering societies, including, of course, the Institution of Civil Engineers. His death occurred on May 16, at the age of 76.

NOTES.

Optical Research and Chemical Progress.

In his two Royal Institution lectures on "Optical Research as an Aid to Chemical Progress," delivered on the last two Tuesdays, Dr. T. M. Lowry, F.R.S., Lecturer on Chemistry at Guy's Hospital, dealt chiefly with the optical side of the problems, which are hardly understood by some users of polarimeters and quartz plates. Dr. Lowry introduced his subject by an interesting historical reference. The first account of the discovery by Biot of rotatory power (circular polarisation) was given in 1817 in the *Memoires de la Société d'Arcueil*, a body of brilliant scientists—La Place, Biot, Gay Lussac, A. von Humboldt, Arago, &c.—who met in Berthollet's house near Paris. Biot placed a plate of quartz (cut at right angles to the optical axis) between the crossed nicols; the dark field became bright again, and when the analyser was rotated, the original colour of the field (depending upon the plate thickness) changed, say, from yellow to orange, pink, violet, blue, green. With the aid of diagrams (coloured rings) Dr. Lowry explained the colours. The rotated ray described a corkscrew path, the violet was more rotated than the red, and if the violet were turned through 180 deg. and extinguished (supposing extinction to be in the vertical plane) by a plate of a certain thickness, then the blue would be in the position of extinction in a slightly thicker plate, and so on; and the extinction would repeat after two, four, six, &c., right-angles. The extinction could also be shown as a dark band on the spectrum of the ray. When the plate was too thick (or also too thin), and the final rotation amounted to thousands of degrees, there would be so many partial extinctions that the eye could no longer detect any selected absorption. Such a plate, *e.g.*, a quartz cylinder, 50 mm. thick, would, however, give a spectrum crossed by dark bands in all the colours. Now some quartz crystals turned the plane of polarisation to the right, some to the left, and it was noticed that the former had certain peculiar facets to the right of the axis. Thus optical power and crystal structure seemed to be inter-connected. But Biot himself also observed in 1818 that some liquids (sugar solution, turpentine) and even vapours were optically active. The column of turpentine vapours which he produced in an old church, and which finally caught fire, had a height of 30 metres. Then Pasteur succeeded in demonstrating that tartaric acid gave three series of salts, being dextro- and lævo-rotatory, and optically inactive (only the first and last had so far been known), distinguished by right-handed or by left-handed crystal facets, or by both, and Van't Hoff and Le Bel connected optical power in general with a molecular, not merely a crystallographic, asymmetry. That ammonia was asymmetrical in certain complex organic compounds had only recently been established. The study of the similar rotation produced by magnetic fields attracted Sir William Perkins more than his colours. As regards the law of rotation, Biot gave the formula $a = k/\lambda^2$ or $a\,\lambda^2 =$ constant, where a was the rotation for the wave-length. That law held perfectly for quartz, but not more than approximately for other substances and solutions (whose rotation, moreover, changed slowly or rapidly with time—muta-rotation—especially in the presence of acids or alkalies), and not at all for tartaric acid itself (which showed "anomalous dispersion," the rotation being maximum for the green, not the violet). Thus Biot's law became discredited, until Drude proved in 1897 that it only required a modification. The question had been discussed by the Faraday Society in 1914,* and Rupe had since then further shown that a great many organic compounds obeyed that law, which was most easily recognised when $1/a$ was plotted against λ^2, as Dr. Lowry had proposed. Dr. Lowry further dwelt on the use of the mercury and cadmium spectrum lines (instead of the sodium lines) for such researches, and on his enclosed cadmium-vapour arc lamps. We have described these lamps, as well as the beautifully simple cadmium vapour arc of Dr. Sand, which was likewise shown, on other occasions.

Cast Projectiles.

In the issue of May 27 of *Le Génie Civil* is given an illustrated description of the manufacture of cast projectiles; these are of cast-iron, the greater part now made being, however, of cast-iron with an admixture of steel, the two melted down together. Our contemporary adds that cast-iron projectiles have very frequently been used for the sake of cheapness in firing practice at sea. Cast projectiles are manufactured in large quantities and for all calibre guns. Machining is generally the same as in the case of forged-steel projectiles; in some cases, however, in that of 90-mm. (3½-in.) projectiles, for example, the base, band seating and shoulder alone are machined, the cylindrical part and ogival head frequently being left rough cast. The specification of July 31, 1915, gives some indications concerning the quality required for the cast-iron. The mechanical tests are carried out with test-pieces 200 mm. (7⅞ in.) in length, 40 mm. ($1\frac{9}{16}$ in.) square; these test pieces are placed on knife-edge bearings 150 mm. (5⅞ in.) apart and are subjected to a falling weight of 12 kg. (26.45 lb.), the average height of fall of which has to be at least 450 mm. (17¾ in. bare). Tensile tests are made on specimens 150 mm. (5⅞ in.) long, cast at a diameter of 18 mm. ($\frac{11}{16}$ in.) and turned down to 16 mm. (⅝ in.); these have to withstand a tensile stress of 25 kg. per square mm. (15.87 tons per sq. in.). When machined, the shells have to withstand during 10 seconds a water-tight test at a pressure of 300 kg. per square cm. (4267 lb. per sq. in.) when the calibre is equal to or below 160 mm. (6¼ in.) and a pressure of 200 kg. per sq. cm. (2845 lb. per sq. in.) for the larger calibres. The new specification does not define the analysis of the cast-iron. An appendix to a former specification dated November 1, 1914, gave, simply as an indication, the following figures:—

Silicon	...	1.25 to 1.50 per cent.
Manganese	...	0.50 to 0.70 per cent.
Sulphur	...	0.07 per cent.
Phosphorus	...	0.07 per cent.

The percentage of carbon was not stated. The artillery qualities AM or BM of pig-iron were recommended; these have the following analyses:—

	Silicon.	Manganese.	Phosphorus. Less than	Sulphur. Less than
	Per cent.	Per cent.	Per cent.	Per cent.
AM pig-iron	... 1.75 to 3	1.50	0.09	0.05
BM pig-iron	... 1 to 1.75	1.10	0.09	0.005

In case these grades were not available, the grades A or B were to be taken, with an addition of 15 to 18 per cent. of steel; the coke consumption for the heat in the cupola furnace being from 15 to 18 per cent., with a pressure of blast equal to a water column of 450 to 500 mm. (about 18¾ in.). The above figures can, however, be varied within somewhat wide limits and the results be satisfactory. The percentage of silicon in the final product can also vary somewhat largely, provided the proportion of manganese follows in like progression. The cast-iron may have any of the following compositions, all of which give results equally satisfactory:—

	Per Cent.	Per Cent.	Per Cent.
Silicon	1.50	2.20	1.40
Manganese ...	0.44	0.98	0.70
Phosphorus ...	0.174	0.10	0.09
Sulphur	0.095	0.07	0.06

The "steely cast-iron" now largely used is obtained in various ways, directly or by mixture, in the open-hearth furnace, the converter, the electric furnace, or the cupola. The melting in the cupola is the simplest process, and the one most followed. The charge consists of a mixture of pig-iron high in silicon, about 2.5 per cent., the manganese being between 0.8 and 1.25 per cent., to which an addition of from 30 to 40 per cent. of steel is made, unless high-class hematite pig is available, which allows a reduction in the proportion of steel added. The loss of silicon in the melting process, which has to be taken into account, is 0.2 to 0.3 per cent. Projectiles cast of steel alone would not have sufficiently smooth and sound surfaces. Cast-iron alone is not suitable for shells containing a high explosive charge, whilst cast-iron with an admixture of steel solves the difficulty and yields shells having a sufficiently low dead weight. In these latter, the wall thickness is greater than that of wrought-steel shells, but the shells of "steely cast-iron" contain a sufficiently large high explosive charge to produce remarkable effects.

Building of Wooden Vessels.—According to *Canadian Machinery*, so great is the demand for Canadian tonnage that it has been found necessary to revert to the building of wooden vessels of the sailing type, a condition somewhat unique in the shipping world. When steel-built vessels supplanted the wooden craft, few of which have been constructed in recent years, it was never thought that the old-style craft would ever be revived. War has, however, changed conditions, and incidentally brought about a condition of affairs on the upper lakes that was never dreamt of before the war started. One firm alone has orders for 10 four-masted sailing ships of 1200 tons gross, which are to be used in the North and South American coastwise trade.

German Chemical Works.—At the recent annual meeting of the Badische Anilin und Soda-Fabrik, the chairman announced that a clear profit of nearly 20 million marks had been made in 1915 (against 15 million in 1914), and that after writing off 11¼ million marks, and setting aside one million for a new special invalid fund, while adding three million to the reserve, a dividend of 20 per cent. (19 in 1914, 28 per cent. in 1913) was declared. The same dividend is being paid by the other chief chemical works. The equality of the figure is partly due to the fact that the big chemical dye works have for some years been combined together: the Badische Fabrik (Ludwigshafen), the Elberfeld Farbenfabriken (Bayer and Co.), and the Gesellschaft für Anilin (Berlin) on the one side, and the Höchster Farbwerke, Cassella and Co. (Frankfort), and Kalle and Co. (Biebrich) on the other. In view of the serious outlook, foreign competition, and the difficulties of settling foreign accounts, it was resolved further to unite the groups, and to include the one great outstanding dye firm, Weiler ter Meer, of Uerdingen, in the new combine, in order to watch the common interests of the dye industry. An exchange of experience gained is included in the agreement.

* See Engineering, vol. xcvii., page 478.

LITERATURE.

The Rise of Rail-Power in War and Conquest, 1833–1914. By EDWIN A. PRATT. London: P. S. King and Co., Limited, 1915. [Price 7s. 6d. net.]

MR. EDWIN PRATT, an authority on canal and railway transport, has in this work used his special knowledge to bring home to those untrained in military affairs the strength and weakness of railways in warfare, and to demonstrate the extent to which their employment has revolutionised tactics and strategy. The possibilities of some new engine, untried in actual war, as the submarine and the aeroplane, appeal to the imagination of the public, who are generally ready to credit the unknown and strange with unlimited powers. We are proud of the achievements of science, and eagerly expect some fresh departure in the means of attack and defence, steeling ourselves to submit to the perpetration of unaccustomed horrors and the more wholesale destruction of man and property. But the railway is an old and familiar friend, whose operations can awaken no excitement, and whose capacity we persuade ourselves we have fathomed. Mr. Pratt's story is one that should convince us of our error; it is one of gradual, and not of exhausted, progress, and is not the less instructive because no new invention is seen in operation, no sudden and unexpected adaptation of scientific ingenuity is forthcoming. It is a story of success won by accumulated experience in paths that attract little attention, of small amendments, the result of constant watchfulness striving to improve and perfect an organisation that has made war possible on the scale in which we see it waged to-day.

In descriptions of battles and sieges we are told of the heroism of our soldiers, of the impetuosity of their attack, of their steadiness under fire, of all the pageantry of war, and we conjure up the scene as perfectly as we can; but we take it for granted that the men are on the spot, that horses and guns, ammunition and stores are at hand; that in some way the necessary provision for all contingencies can be supplied. Yet the machinery for moving an army, for keeping the men supplied with necessaries, calls for generalship hardly second to that which brings victory; and our gratitude and admiration should be as readily extended to those who provide successfully for an efficient transport as to those who occupy a more prominent place in the campaign. The time has not yet come for telling what the railways have accomplished during this gigantic struggle, but we do know that they have met the requirements of the military authorities. If, given the men and the material collected at a particular spot, it seems a light thing to move all rapidly and safely, it is because we do not adequately conceive the magnitude of the task, and very imperfectly comprehend all that is involved in handling such quantities of impedimenta, with the troubles that follow congestion when the scheme fails to work smoothly. Mr. Pratt's examples of failures in the past, when armies and stores were of modest dimensions, should teach us something of the work accomplished to-day. Success is the triumph of detailed organisation, of foresight and skilful training, of systematic preparation and repeated drilling.

The possibilities of railways in facilitating transport first dawned on the military authorities in 1830, when a British regiment was conveyed from Liverpool to Manchester in two hours. To have marched a similar distance would have required two days, and the men would have been far more exhausted on arrival. But it was not till 1842 that precision was given to the vague plans that the unofficial mind suggested. About that time a scheme for the construction of a network of strategic railways covering the whole of Germany was carefully elaborated, the promoters urging that such a network would enable Germany to carry on war simultaneously on two fronts—France and Russia. These views at the time were premature, but they fructified, and the full fruition is seen in our own day. The progress was not so rapid, nor was the problem so easily solved, as the originators planned, for, in 1850, an Austrian army of 75,000 men, 8000 horses and 1000 vehicles, occupied no less than twenty-six days in covering 150 miles, from Vienna to the Silesian frontier, and it was admitted that the men could have marched the distance in a shorter time. It was not till nearly ten years later, in the Italian campaign of 1859, that railways first played a conspicuous part in actual warfare, both strategically and tactically. This, of course, was subsequent to our experiment in the Crimea, when, with infinite pains, we constructed a little military line between Balaclava and the camp before Sebastopol, and exhibited no great competency in the task.

The American War of Secession demonstrated the true capabilities of railways in warfare and taught all nations a valuable lesson. The stage on which that drama was played was large enough to give full scope to transport schemes; armies were necessarily at a considerable distance from the base of supplies, and could only be maintained by the use of railways worked effectively. Another phase was also developed: each belligerent saw the importance of destroying or incapacitating the railways of the other. Hence arose the necessity for creating a special corps for the reconstruction and repair of damaged lines after successful raids. Finally, it was perceived that the military element was incapable of controlling and operating the system with effect, and to ensure efficient service civilians, trained in railway management, had to be requisitioned and endowed with authority co-ordinate with that of the military. These were the main directions in which the experience gained from the American War improved railway organisation, and it is on these lines that all subsequent improvements have turned. The Federals were fortunate in having at command men of enterprise and resource. Rapidity of repair was brought to a fine art, and offered to European nations a model and an example that they have hardly surpassed. It was shown that it was practically impossible to destroy a railway or render it ineffective for a lengthened period. The Americans claimed that a bridge could be repaired "about as fast as a dog could trot," and there was little exaggeration in the phrase. When a bridge was burnt down near Fredericksburg, a new one was put up in its place in half a day! The Potomac Creek bridge, 414 ft. long and 82 ft. above water-line, was completed in nine days, and sufficiently reconstructed for military trains to pass over it in forty working hours. Such quick repairs gave confidence to the generals, who had been exceedingly chary in getting far away from the magazines on which they depended for supplies. But the factor of greatest efficiency was the control of the traffic by railway men skilled in the mechanism and experienced in the details that ensure effective operation. Congestion and dislocation of traffic, which were frequent troubles when railways were worked under orders issued direct from the Secretary of War or by Army commanders in the field, disappeared under competent control. Students of military matters, who have ridiculed the American forces as armed mobs rather than armies, learned for the first time that it was possible to furnish an army of 100,000 men and 60,000 animals with supplies from a base 360 miles distant by a line of single-track railroad, located almost the entire distance through the country of an active and vindictive enemy. Jealousy and interference by military officers are not likely to occasion trouble in the future; the lesson has been too thoroughly learnt; but that railway men are somewhat mistrustful of the military element is shown by the answer Sir C. Owens made to the Secretary of War, who inquired if the railways of the country could cope adequately with any emergency that might arise. "I will stake my reputation as a railway man," said Sir Charles, "that the country could not concentrate men and materials half so fast as the railways could deal with them; but the management of the railways must be left in the hands of railway men."

To the American War we owe another innovation, that of the armoured car or train; but this did not come into favour rapidly. It is, however, asserted that in general appearance and outline the American pattern much resembled those of the present day, the chief difference being that the locomotive was not sheathed in armour. On the other hand, bullet-proof cabs of locomotives were in frequent use and gave satisfaction. Armoured trains with some improvements were utilised in the Franco-German War, and were recognised as an ordinary and valuable weapon in the South African Campaign.

It is a more pleasant task to report the beneficent services railways have rendered in the prompt removal of the sick and wounded from the theatre of war, with consequent diminution of suffering and of the chances of spreading disease and pestilence among the non-combatant population. The army collectively and the individual have alike been benefited. By the quick removal of the wounded the army acquires greater freedom of movement, the number of efficients is not reduced by the necessity of finding nurses, and the inevitable wastage is diminished by the quicker return of convalescents to the colours; the individual escapes the risk of overcrowding in field hospitals, enjoys the advantages of a better surgical technique, of skilled attention in nursing, and is spared much of the misery of sickness. But though the advantages are easily appreciated, the improvements came slowly. The little railway at Balaclava was the first to be used for the conveyance of wounded, and the facilities provided were of the most primitive character, and not available for the worst cases. Straw on the floor of goods or cattle-trucks was the utmost luxury the department extended to the wounded or sick soldier. American resource, developed in the War of Secession, again led the way, and though in the early months the arrangements were crude and immature, accumulated experience continually improved the machinery till the outlines of the modern hospital on wheels came in sight. The Danish War of 1864 showed the defects of the Prussian organisation, and the conditions in the campaign of 1866 were lamentably imperfect. After the battle of Sadowa the attention bestowed upon the wounded was as indifferent as in Napoleonic times. Whatever may be the talent for organisation possessed by the Germans, it was not exhibited in the form of hospital accommodation and care of the wounded. In the Franco-German War the "sanitary trains" left much to be desired, viewed in the light of the perfected machinery of to-day. The Boer War marked further improvements both in hospital trains purposely constructed, and in suitable adaptation of existing rolling-stock. The ambulance motor-car is the product of the present war.

From the survey of general progress to which all nations have contributed, Mr. Pratt passes under review the existing organisation in the military countries of Europe and the lines of development each has pursued. Germany, he contends, can lay no special claim to merit in regard to her preparations for the Franco-German War. The general scheme was elaborate enough, and the quantity of men and materials carried was so vast that a certain degree of success may be allowed, but in points of detail the shortcomings were many and glaring. The author asserts that little improvement was shown in advance of the 1866 campaign, notwithstanding the recommendations of several commissions of inquiry. The French transport service of that date was governed by the regulations which bore the date of 1851-5, and were so utterly inadequate that confusion rapidly approached chaos. The description of the early days of that disastrous conflict is not edifying, but contrasts very vividly with the efficient scheme of military transport which has been evolved since, and been continually tested at every available opportunity. The degree of perfection attained is a proof of the ardour with which the French have worked on this problem of rail-power, and the exertion and sacrifice ungrudgingly given show the importance Continental nations attach to an effective scheme of rapid transport.

The conditions prevailing in England are necessarily peculiar from the fact that sea-borne traffic must be included, that the railway lines are not State property or subsidised by Government, and the Standing Army relies on voluntary enlistment. In such a combination the Railway Volunteer Staff Corps finds an appropriate place, and figures largely in all draft schemes. An Army Railway Council acts in a purely advisory capacity, and considering

the smallness of the Army to within quite recent date, the regulations and machinery have proved sufficient. No doubt from a German point of view the organisation would be regarded as defective and amateurish, but when put to an actual trial, as in the case of the Boer War, there is evidence to show that the whole transport operations, at times very severe, were conducted with perfect smoothness, without any over-taxation either of the railway facilities or of the dock accommodation.

The chapters on military and strategical railways, properly so-called, are instructive. Such railways may be considered both from the point of view of what they have effected and to what purposes they can be put. To illustrate past history, the Trans-Siberian Railway, on which the Russian Army was mainly dependent in the Japanese conflict, not only for the concentration and maintenance of the army, but for the raising and organisation of its units, may be cited. It furnishes a striking example of the deficiencies which can mar an imposing military undertaking. The Russians had known and suffered from the want of railways in the Crimean War, and they rightly recognised that if their aims were to be realised in the Far East a great strategic line must be stretched across Asia. It was an immense project, well conceived, and one that taxed the pecuniary resources of Russia severely, so severely that the economy, misplaced, but imperatively demanded, was fatal to its effective construction. In the hour of trial the hopes built upon its performance proved fallacious. There was only a single line of rails, the curves sharper than were consistent with speed or safety, the gradients steep and varied, the rails too light and ill-laid, while Lake Baikal cut the line in two parts, destroying continuity. The number of trains was limited, and the speed averaged only about seven miles an hour. With these drawbacks it is not surprising that seven months were required to transport three army corps from Russia to Manchuria. General Kuropatkin asserted that a single extra through troop train per day would have made a material difference, and believes that if the Russians could have run six trains daily continually from the start the initiative and the victory would have been theirs. Whether this view be well founded or not we need not consider. The point that the least observant should keep in view is that railways annihilate distance, and make the frontiers of nations, whether friends or enemies, conterminous. The base of supplies is made to embrace the whole of the country with which the railway is connected, and the long thin steel line, so slender and apparently so easily broken, forms nevertheless a strong and trustworthy link on which the general in the field can safely rely. It is easier to criticise the mistakes and achievements of the past than to forecast the future, but the author, impressed by what railways have done, and convinced of what they will do, devotes two chapters to the intrigues of German organisation for controlling national extension. Not without sufficient reason does he show how the ambitions of Germany may be realised on the African Continent by skilfully-planned aggressive railways, and he may well emphasise the danger that threatens our interests in Egypt and India through the possession and operation of the Baghdad railway. The tactics of Germany work silently and skilfully to their end, but those who wish to ignore them will ignore them. They are nevertheless painfully apparent to the student of military tactics. In this connection it may be permitted to repeat the words of the Duke of Wellington, who, looking at the dangers by which the country was menaced in his time, wrote: "I hope that the Almighty may protect me from being the witness of the tragedy which I cannot persuade my contemporaries to take measures to avert."

The Analysis of Non-Ferrous Alloys. By FRED IBBOTSON, B.Sc., B.Met., A.R.C.Sc., and LESLIE AITCHISON, M.Met. Longmans, Green and Co. [Price 7s. 6d. net.]

THE chemical literature on non-ferrous alloys has hardly kept pace with the increasing importance of the alloys themselves and lags behind that of ferrous alloys. A volume on the Analysis of Non-ferrous Alloys is therefore decidedly welcome. We are not sure, however, that Messrs. Ibbotson and Aitchison should not more strictly have spoken of "analytical determination of the metals of the non-ferrous alloys" than of "analysis of non-ferrous alloys"; for 170 out of 230 pages altogether (including logarithmic tables and index) are devoted to general analytical practice and to eleven chief metals, whilst we enter upon analysis of commercial alloys only in the last chapter with page 171. We do not object to the sequence, of course, and in a certain sense, moreover, all metals are naturally alloys. But we should expect more attention to be paid to the peculiarities of treatment which certain alloys require as to modes of solution, &c. The alloys discussed are brass, bronze, manganese bronze, phosphor bronze, aluminium bronze, phosphor tin, German silver, lead-antimony-tin alloys, and white metal alloys in general. The eleven chief metals previously dealt with in special chapters are: lead; copper; bismuth; antimony; tin; arsenic; arsenic, antimony and tin separations; aluminium and chromium; nickel; cobalt; zinc. We notice the absence of cadmium and magnesium, which enter into important alloys, but are not referred to at all, so far as we are aware, whilst iron, an undesired constituent of many metals and alloys, is duly considered; electroplaters may wonder why nothing is said about silvered and gilt metals. There is in most cases a general section for each metal before the various analytical methods, gravimetric, volumetric, electrolytic, &c., are described in detail. That section might in the case of copper mention that electrolytic copper may contain cuprous oxide; the electrical engineer does not want this oxide and would like to know how to determine it. The remarks on nickel and cobalt are hardly quite up to date, but the most recent important literature on these metals was probably not available at the time the authors closed their manuscript. As to literature references the different chapters differ; they may be ample or scarce. The two pages of logarithms and anti-logarithms might well have been spared to make room for a more detailed index. In the preface the authors allude to the "time-honoured processes redolent of unlimited time and sulphuretted hydrogen." But they very properly set apart one of their three introductory chapters to Precipitation by means of Hydrogen Sulphide; the two other chapters are on Apparatus for Electrolytic Analysis and on Electrolytic Analysis.

If the omissions and limitations, to which we have drawn attention, had been pointed out by the authors, the reviewer would have been disarmed; for the book is in the main good, as would be expected from the well-known workers in the Metallurgical Department of the University of Sheffield.

BOOKS RECEIVED.

Canada Department of Mines. Petroleum and Natural Gas Resources of Canada. In Two Volumes. Vol. II.—*Description of Occurrences.* Ottawa: Government Printing Office.

United States Geological Survey. Professional Paper 95 D.: An Ancient Volcanic Eruption in the Upper Yukon Basin. By STEPHEN R. CAPPS. Washington: Government Printing Office.

United States Geological Survey: The Mesozoic and Cenozoic Echinodermata of the United States. By WILLIAM BULLOCK CLARK and MAYVILLE W. TWITCHELL. Washington: Government Printing Office.

British Destiny: The Principles of Progress. By D. N. DUNLOP. London: The Path Publishing Company, Oakley House, Bloomsbury Street, W.C. [Price 3s. 6d. net.]

Paint and Colour Mixing: A Practical Hand-Book. By ARTHUR SEYMOUR JENNINGS. Fifth Edition. London: E. and F. N. Spon, Limited; New York: Spon and Chamberlain. [Price 6s.]

United States Department of the Interior. Bureau of Mines. Bulletins. No. 94. *Law Serial* 4. *United States Mining Statutes Annotated.* Part I.: *Sections and Statutes Relating to Metalliferous and Coal-Mining.* Part II.: *Miscellaneous Mining Subjects.* By J. W. THOMPSON. No. 101: *Abstracts of Current Decisions on Mines and Mining, October,* 1914, to *April,* 1915. By J. W. THOMPSON. Washington: Government Printing Office.

Homeland Hand-Books. Vol. 85: *Penzance and the Land's End District.* By J. B. CORNISH and J. A. D. BRIDGER. With Town Plan, Illustrations, and Photographs. London: Homeland Association, Limited, Maiden-lane, Covent Garden, W.C. [Price 6d. net.]

THE KING'S BIRTHDAY HONOURS.

THE list of honours conferred by His Majesty on the occasion of his birthday, upon the recommendation of the Prime Minister and other State Departments, is more largely naval and military, but certainly not less political, than usual. That magnificent service has been rendered to the Army and Navy by many industrialists can scarcely be recognised from a study of the list, and we hope that it is a case of deferment rather than of ignoring the great services rendered. We could name many industrialists entitled to honours, from the peerage downwards, for displaying over a long series of years that enterprise and technical ability which have enabled the nation to rise to its highest productive capacity; and men also who, during the past twenty-three months, have worked incessantly and with great originative and administrative capability, who are entitled to an equal if not a greater degree of recognition.

Amongst the new Privy Councillors is Mr. Charles William Bowerman, the Labour Member of Parliament for Deptford since 1906. He, for many years, had great influence in the trade-union movement, having been president of the Trade-Union Congress in 1901, while now he occupies the position of Parliamentary Secretary of the London Society of Compositors. The Chairman of Lloyd's Register of Shipping, Mr. Thomas Lane Devitt, who is also an associate member of Council of the Institution of Naval Architects, has been made a baronet, as has also Mr. E. W. Moir, member of the Institution of Civil Engineers. For many years he has been a partner in the firm of S. Pearson and Sons, Limited, the public works contractors, and has been responsible for many important engineering undertakings. Soon after the outbreak of war he became the Comptroller of Munitions Inventions, but has for some time represented the Ministry of Munitions in the United States.

Amongst the Knights are Mr. John Anthony, a partner in the well-known firm of valve manufacturers, Messrs. Cockburn Brothers; Dr. George Thomas Beilby, the well-known chemist—amongst whose contributions to industrial efficiency are his experiments on fuel economy; Mr. E. C. Geddes, who was Deputy General Manager of the North-Eastern Railway until he took up the duties of Deputy Director-General of Munitions Supply; Mr. Edward Nicholl, Commander, R.N.R., a Cardiff shipowner and a director of the Taff Vale and other railways; and Mr. G. H. West, who was formerly an important member of the staff, at Elswick, of Sir W. G. Armstrong, Whitworth and Co., until he became Deputy Director-General of Munitions Supply. The Colonial list includes a Companionship of the Order of St. Michael and St. George, conferred upon Mr. Archibald Samuel Cooper, General Manager of the Nigerian Railway.

The list of appointments and promotions in the Most Honourable Order of the Bath includes recognition of several naval and military officers who have done important executive and fighting service. We are glad to note the conferment of a C.B. upon Engineer-Captain Fred Hore, Engineer-Captain Donald Percy Green, Engineer-Rear-Admiral Ernest Frank Ellis, Captain Thomas Evans Crease, R.N. (ret.) (identified with the Coventry Ordnance Company); Mr. William Henry Gard, M.V.O., of the Royal Corps of Naval Constructors; Colonel Charles Frederick Close, Director-General of the Ordnance Survey and formerly of the Royal Engineers; Lieut.-Colonel Norman Mackenzie Hemming, R.E., Superintendent of the Building Works at the Royal Arsenal, and Captain M. H. P. Riall Sankey, late of the Royal Engineers, closely identified with the development of the Marconi system of wireless telegraphy. An M.V.O. of the Fourth Class has been conferred upon Engineer-Lieutenant-Commander R. C. Hugill, late of the Royal Yacht Victoria and Albert.

THE INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS.—The forty-third annual general meeting of this institution is to be held at the Town Hall, Blackpool, on Thursday, Friday and Saturday, June 29 and 30 and July 1. The papers to be read and discussed number fourteen, and the programme includes a number of visits to various places of interest.

ORGANISATION OF BRITISH ENGINEERING INDUSTRY.—The following resolutions were carried at the general meeting of the Council (Manufacturing Engineering Concerns Section), held in Manchester on June 6, 1916:—(1) That this meeting approves the steps taken to organise British engineering industry by the Council appointed on December 6, 1915. (2) That this meeting approves the formation of an association on the lines advocated in the Memorandum circulated, with power to negotiate and if advisable to amalgamate, or combine, with existing or projected Associations; and this meeting pledges itself to support such an organisation. (3) That those firms who by signing the card have promised their adhesion and support to the organisation be asked to subscribe to the funds of the new Association and to make forthwith a minimum payment of 5*l.* on account of their first year's subscription towards preliminary expenses. (4) That the existing Committee be empowered to give effect to the resolutions passed at this meeting.

THE CEMENT GUN.

THE CEMENT GUN COMPANY, NEW YORK.

Fig.1.

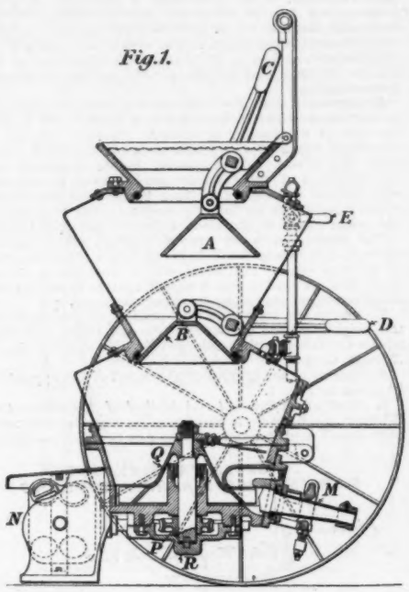


Fig.2.

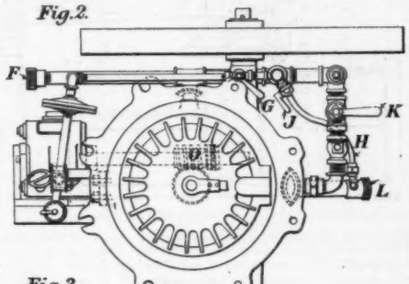


Fig.3.

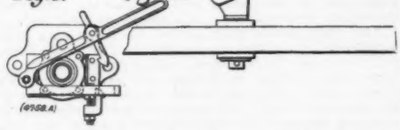


FIG. 4. REPAIRING DEFECTS ON A CEMENT WALL ON THE DELAWARE, LACKAWANNA, AND WESTERN RAILROAD, U.S.A.

THE "cement gun" is a device which has been fairly thoroughly tried in the United States and found to perform well such operations as the application of coats of cement mortar to surfaces in general. The mortar is applied by a jet action. In fact, the surface to be coated is bombarded by the cement—hence the name. The forcible impact is useful, as thereby attachment is facilitated and compactness secured. The coats may be quite thin—say ¼ in. thick—or, by repeated application of the jet, the thickness may be increased to an indefinite total. As a flexible hose may be used to connect the machine and discharge nozzle, the operator is able to work upon surfaces in almost any situation.

The cement gun is well adapted for such work as the application of cement plaster coats to the walls and ceilings of fire-proof buildings. An instance of this description occurred some time ago at Whitby, Ontario, Canada, where the authorities were engaged in the construction of fire-proof cottages for the Hospital for the Insane. A protective coating was applied not long ago to the structural steel of the Cortlandt-street Ferry Terminal of the Pennsylvania Railroad at New York City. At Nashville, Tennessee, the cement gun was employed to effect the repair and water-proofing of the water-works reservoir. The up-stream face of Elephant Butte Dam has been water-proofed by a 1-in. coating of Portland cement mortar applied by this machine.

The apparatus is operated by compressed air. The air is used to drive a small motor which supplies the power for the mechanical operation of a feeding-wheel, and also to supply the stream or jet which carries the material to its destination.

The engravings on this page illustrate the details of a recent form of the machine brought out by the Cement Gun Company, of 30, Church-street, New York. For convenience in shifting its location, the machine is mounted on wheels. Fig. 1 shows a vertical section through the common axis of the pair of main hoppers constituting the bulk of the machine. Fig. 2 is a plan through the joint where the upper and lower sections of the bottom hopper are bolted together. We will assume for the present that all valves admitting compressed air are closed and that the valve controlling the discharge of material from the machine is also shut off. There are two cone valves, A and B, operated by the control levers C and D. These valves close the main openings into the two principal hoppers. With the entrance to the lower hopper closed and that to the upper one open, the material is put in by way of the small hopper at the top. This material must be neither too dry nor too wet. Additional water is supplied as the mortar passes out from the machine into the flexible hose. The upper main hopper will have its charge secured at the moment when the upper cone valve has returned to its seat. The lower cone-valve is held in position during the period of charging. It is now released and the upper cone-valve closed, the upper lever C being held until the air pressure in the double compartment is sufficient to keep the valve shut. This pressure is created by opening the air-supply valve E. A disc having a $\frac{1}{16}$-in. hole and arranged in a union on this air-supply line is employed to prevent a too sudden withdrawal of air from the main line.

On the plan, Fig. 2, may be observed at F the point where the air-supply hose is connected. The supply-pipe may be traced to a point just beyond the right-hand trunnion on which one of the wheels is mounted. Here a connection is arranged providing for two diversions of air. One of these returns by a small pipe parallel to and in the same vertical plane with the main supply-tube. This diversion leads to the air-motor and is controlled by the cock G. The other diversion is guided through the tube H, and is controlled by the cock J. The main supply-pipe proceeds, however, and enters the lower main hopper after making two right-angled turns. This air is controlled by the cock K. Vertically beneath the short length of the main supply-line, which is located after the final turn, is the discharge-tube of the machine L. This discharge-tube may be observed on the vertical section (Fig. 1) at M. It is really flexible and subject to control by the pinching action of the lever shown in the small detail drawing at Fig. 3. Above the inner end of the flexible discharge-tube may be seen the inner terminal of the main air supply to the machine. It will be noted that the air is delivered downwards. This air supplies the discharge-jet. At the end of the flexible discharge-tube provision is made for the entrance of water into the mixture of air and material passing along. The back pressure of the water is kept at about 20 lb. per sq. in. higher than the back pressure of the air forming the jet.

Let it be recalled, now, that we have the charge in the machine, the lower cone-valve released, and a compressed-air supply coming in through the cock E. The cock K is next opened and air admitted into the machine for the jet. Next the cock J is opened on the by-pass tube and air is sent into the discharge-hose without passing it through the machine. This results in a preliminary clearance of the hose and the creation of a suction in it. The cock G is now opened and air admitted to the motor N.

The operation of the motor results in the rotation of the worm O, which transmits a slow rotational movement through the gear P to the feed-wheel Q. This wheel is mounted for rotation on a vertical shaft, carried on a footstep at R. Around the periphery of the wheel are arranged numerous compartments open above (Fig. 2) and at the side. As the wheel rotates, these compartments carry the mortar in small amounts beneath the delivery end of the air supply for the jet. The openings on the outer edge permit the jet to drive the material into the discharge-pipe. Naturally, however, this action will not begin until the pinch-lever has been released. It is secured by a latch and a catch, the latter being adjustable. When everything is ready, the latch is kicked loose by the foot. The motor may now be run faster and faster until the possible or the desired rapidity of operation is secured. Water is kept flowing at the discharge-point and its amount kept equal to the double requirement of dustless material without excess of water. There is a small cock which admits air to the lower main hopper. This is kept open during actual operation. The operator in charge of the cone-valves keeps trying the lever of the lower valve to see if it may be closed. When it is possible to shut the valve, this fact indicates that the upper main hopper is clear of material. The lower cone-valve is held in this closed position, the cock E is turned off, and the exhaust-cock for the upper main hopper opened. The upper cone-valve will now drop open, while the lower one will be held in position by the air pressure in the lower main hopper. Another charge is now put into the machine, the upper cone-valve closed by hand and the cock E slowly opened. The exhaust-cock should, of course, be closed prior to this last operation. The weight of the material on the lower valve plus the increasing pressure of the air in the upper main hopper will after a time cause the lower cone-valve to drop.

It will be seen upon reflection that the upper main hopper is really an air-lock, corresponding to the devices used in pneumatic excavation for the purpose of admitting and releasing men and materials from the caisson while it is under pressure. The air-pressures deemed best for ordinary applications range between 35 and 45 lb. per sq. in. However, a first coat may be put on at pressures 40 per cent. higher. The high pressures are also permissible when increased capacity is desired upon rough work.

At Whitby, Canada, where the Hospital for the

Insane is located, both interior and exterior work was performed by the cement gun. A coating ¾ in. thick of stucco plaster was applied in one coat. On the interior a coating of ½ in. thickness was used. The exterior plaster was made from sand and a mixture consisting of calcium aluminate extracted from Cuban slag and of hydrated lime, the respective percentages being 20 and 80. This mixture of limes has a high carrying capacity for sand, resulting, so it is claimed, in reduced cost and diminished expansion and contraction of the finished stucco. It will be seen from this example that the use of the cement gun is by no means limited to Portland cement mortar.

The protective coating applied by the cement gun to the steel substructure of the Cortlandt-street Ferry Terminal is, perhaps, as interesting and instructive an example of the use of the machine as may be cited. The protection of this steel constituted a perplexing problem. The metal is exposed to severe conditions, being located about 4 ft. above high water at a point on the North River where the water is very salt. Steam in considerable quantity escapes at low-water from drips and drains which pass through the bulkhead wall. The surface of the steel is said to have been continuously wet. After erection and cleaning with wire brushes, two coats of standard paint were applied. In a short time the paint peeled off. The steel was cleaned over again and asphaltum applied. In six months it could, so it is said, be dusted off with a broom. The steel was then left to take care of itself for a number of years, when the engineering department found that some protective measures had to be adopted. The cement gun was thought to be a possible solution, but the first plan for using it was considered too expensive. This plan contemplated using the gun in a way in which its work had been pretty well tried out—that is to say, it was proposed to cover the steel beams with a wire mesh and then to apply the mortar until a coating was built up of sufficient thickness to fill in the space between beam and netting and, in addition, to cover the latter with a protective layer. The necessary thickness of mortar was estimated at 1½ in. If, however, the wire netting could be omitted, then the thickness of the coating could be greatly reduced and the cost of the netting and its installation saved. Some rather severe experiments were then tried, in the course of which a thin coating of 1 : 3 mortar, varying from ¼ in. to ½ in. in thickness, was applied to a short length of angle iron and then tested in moist salt air for three days, then in salt water for three days, in cold storage at 5 deg. below zero Fahr. for two days, and in heat at 110 deg. for three days. A 2-ft. drop on to a wooden floor and then on to a cement floor was used to test the coating further. Some of the coating was forcibly broken off, when the steel was found to show no signs of incipient rusting. Apparently none of the tests was productive of flaking or of hair-cracks.

In dealing with the substructure steel, it was first sand-blasted down to grey metal. The coating was then applied with a cement gun, the total thickness ranging from ¼ in. to ½ in. The possibility of using the coating without reinforcement was due, no doubt, largely to the fact that the steel substructure had been designed to carry the loads with but little deflection.

A standard method of applying mortar with the gun is, as intimated above, to use a network of wire as reinforcement. There are many situations, however, where no such auxiliary is required. Thus, where neat cement or cement mortar is to be applied to a concrete surface the netting is unnecessary. At Elephant Butte Dam the 1-in. coating has been successfully applied in four layers without the use of reinforcement. Scrapers, wire brushes and the sand-blast were, however, used to prepare the surface. The sand used in the blast was coarse and was applied partly to roughen the concrete. A jet of water was employed to moisten the surface and the cement gun then brought into normal action. The layers, each about ¼ in. thick, were applied, each of the last three upon its predecessor before the latter had come to a final set. The up-stream face of the dam is vertical, or nearly so. Mr. E. H. Baldwin, Assistant Chief of Construction, U.S. Reclamation Service, said, when the work had not yet been completed, that "numerous samples taken from the face showed perfect adhesion to the concrete, it being impossible in every case to break mortar from the concrete at the line of contact." Fig. 4 shows a machine in action repairing defects in a cement wall on the Delaware, Lackawanna and Western Railroad, U.S.A.

AMERICAN CARS.—The American Pressed Steel Car Company has placed a contract for the supply of 1000 cars to the Paris, Lyons and Mediterranean Railway Company, 500 having been added to an order recently given. The Chicago and North Western Railroad Company has placed an order for 1000 wood box cars with the American Car and Foundry Company: and the Anaconda Copper-Mining Company has purchased 200 hopper cars from the Western Car and Foundry Company.

THE EFFECT OF BILGE-KEELS.

*Experiments to Determine the Resistance of Bilge-Keels to Rolling.**

By Professor T. B. ABELL.

1. THE rolling motion of ships has been the subject of many papers in the Transactions of this Institution. These papers have related to experiments on full-size ships and on models; they have also set out purely mathematical investigations on the subject. As far as the author has been able to trace, no experiments have been carried out to determine in ideal conditions the general nature and magnitude of the resistances experienced by regular ship-shape bodies when oscillating in a periodic manner in water. It is a subject which necessarily requires investigation by experiment, since mathematicians have not yet been successful in dealing with or representing the vortex motion set up by bodies, such as thin plates, moving in liquids. There are many directions in which knowledge of such resistances could be applied, and to some purpose, in naval architecture, a notable one being an estimate of the effect of the rudder upon the motion of ships under helm. This paper describes a portion of a series of experiments planned to supply this information. Though the series of experiments is not yet completed, it is thought that there is sufficient justification for publishing some of the results at the present time.

2. Mr. W. Froude made experiments upon a submerged plate oscillating in a direction at right angles to its own plane to determine a coefficient of resistance more or less suitable for estimating the resistance of bilge-keels. The conditions of the experiment, as was known, did not nearly represent the conditions obtaining in a ship in the neighbourhood of the bilge-keel, but it is believed that these experiments are the only ones relevant to the subject carried out under ideal conditions. The large damping effect of the bilge-keel has been the subject of much discussion and surprise. Estimates of its effect based on the experiments of Mr. W. Froude, generally speaking, do not nearly account for the actual results experienced in the ship. It appears that Sir Philip Watts first suggested an explanation of the marked efficiency of bilge-keels in the Transactions of the Institution,† where he says, in reference to the application by Mr. R. E. Froude of the coefficient of resistance obtained from the oscillating plate to an examination of the rolling of the Volage, the Inconstant, and of the Shah: "The excess of the resistance in the case of bilge-keels over that of a plane moving through water is doubtless mainly due to the moment of the pressure produced upon the hull of the ship in the vicinity of the bilge-keels; it will be readily seen that the effect of these pressures will depend upon their direction and position with regard to the axis about which the ship is rotating, and therefore upon the shape of the bottom." Professor G. H. Bryan subsequently corroborated this view by a mathematical investigation presented in the Transactions. The object of the present experiments is mainly to clear up some of the phenomena peculiar to bilge-keel action, and to study the motion of the water in the neighbourhood of the keels or sharp projecting corners in the body.

3. *Conditions of Experiment.*—The object being to obtain in isolation the bilge-keel effect, it was necessary to get rid of all wave disturbance. Though, in the ship, the motion of the water in the neighbourhood of the bilge-keels will be affected by the formation of waves on the surface, and, conversely, the bilge-keels will at large angles of roll, when they approach the water surface, modify the form of the wave, it was thought that the effect in the ship of the wave motion upon the bilge-keel effect would be of the second order for moderate angles of heel. To get rid of wave formation it was necessary to submerge the body, and of the two possible alternative modes of oscillation—viz., about a vertical or a horizontal axis—the former offered less mechanical difficulties, both in the suspension of the body and in making the measurements of resistance or equivalent loss of energy per swing.

4. *The Apparatus.*—The body experimented upon was a prism of constant section, in the first place a square, but subsequently cut down to the general form:—

$$\frac{x^n}{a^n} + \frac{y^n}{b^n} = 1,$$

where n would have different values, from 2 for the circle or ellipse to ∞ for the square or the rectangle. The prism oscillated about its longitudinal axis, and the rate of damping of extreme amplitude is then a measure of the rate of dissipation of energy. For each different section bilge-keels were fitted at each corner, and the rate of damping was measured with and without the keels in position.

5. The side of the square section was 6 in., the length of the prism 12 in. The prism, of wood, was attached by a short brass rod to a circular disc hung by means of a trifilar suspension from a similar fixed disc and oscillated in the central position of a tank 3 ft. by 4 ft. The prism had square ends and was wholly submerged, the attaching rod (¼ in. diameter) was the only portion of the oscillating system breaking the surface. In a trifilar suspension the restoring couple due to the directive force of gravity is proportional to the sine of the angle for all angles of oscillation. The oscillation is not entirely two dimensional, there being, in addition to the angular oscillation, a small linear axial oscillation of the second order. In the actual suspension used, for an angular movement of 12 deg., the double linear amplitude was 0.015 in. At some periods this was sufficient to create surface disturbance involving an appreciable dissipation of energy, and it was necessary to confine the surface of the water. The tank was therefore covered in by boards, the water level being maintained above their upper surfaces, so as to provide a clearance of ¾ in. between the ends of the prism and the bottom of the tank and the bottom of the covering boards. In this way all surface disturbance was effectively quelled. A small steadying pin $\frac{1}{16}$ in. in diameter was fitted at the bottom of the prism to prevent any lateral oscillations accumulating.

It appeared that the tank was sufficiently large to prevent the boundaries having a very marked effect upon the rate of dissipation of energy. Vortices formed at the sharp edges of the prism or keels travelled away from the prism, but dispersed before reaching the boundaries, and there seems good reason to suppose that little of the energy of these vortices—which would entirely escape in an infinite medium—was restored to the prism owing to the limited dimensions of the tank.

The suspension wires were fine piano wires passing through and fitting small holes in brass plates secured to the two discs. Adjusting-screws were fitted at the lower end, so that it was a simple matter to adjust the wires for equal length by levelling the discs.

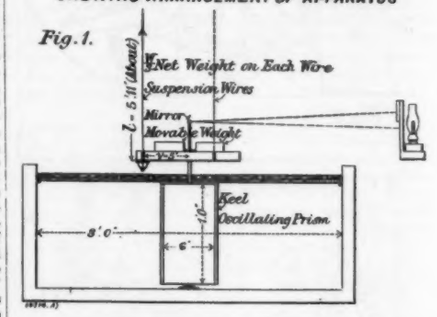
To study the nature of the motion of the water in the neighbourhood of the keels, small tubes with fine bore were fitted so that coloured liquid could be ejected through them.

A diagram of the general arrangement of the apparatus is given in Fig. 1.

6. *Mode of Experiment and Method of Arrangement.*—Without the bilge-keels the forces to be measured were quite small, and it was impracticable to use a recording

SECTIONAL ELEVATION SHOWING ARRANGEMENT OF APPARATUS

Fig. 1.



pen, even though well balanced. To get over this difficulty an optical arrangement for measuring the damping was used. This consisted of a reflecting mirror and scale, the mirror focussing on to a scale of 1 metre radius graduated in centimetres and millimetres. One centimetre thus represented $\frac{1}{100}$ of a radian, or 0.287 deg.

The prism was usually started from rest at a known amplitude, being held in a central position at the instant before release. It was found rather difficult to give it a large free starting oscillation and at the same time ensure getting identical initial circumstances. As it is at large amplitudes that initial circumstances affect the damping appreciably, after several trials it was found preferable to start from rest, for in that way the observations made for successive experiments for the same circumstances repeated themselves exactly. Observations were made at the end of each complete swing—to and fro—and for each condition of loading both in air and in water.

It was quite a simple matter to alter the period of oscillation by altering the weight on the lower disc, and quite a wide range of period could be obtained in this way (with the prism just not water-borne the period is almost infinite). It seemed preferable, however, to use a constant dead load W, and obtain an alteration in period by winging weights to alter the moment of inertia of the system. This ensured a constant restoring couple for various periods, and so led to greater accuracy and ease in reducing the results.

It should be noticed that the conditions of experiment will be comparable with those in the ship if, along the median planes parallel to the side of the sections, the differences of pressure on the two sides of the planes are the same during rest and motion; that is to say, if the motion set up by each quadrant of the section lies entirely within the quadrants formed by the median planes.

7. The results of the experiments here set out are confined to the square section, without and with bilge-keels. These may be divided compendiously under two heads: (1) resistance experiments; (2) period experiments to determine changes of equivalent mass inertia.

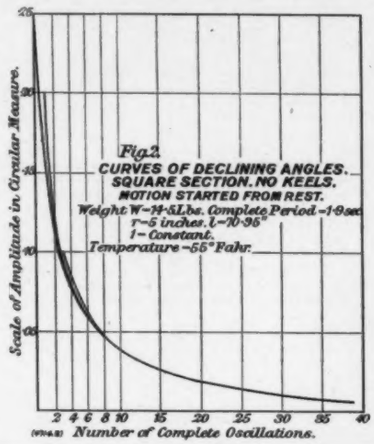
8. *Resistance Measurements.*—The observations were directed to obtaining data for drawing curves of declining angles or damping curves, *i.e.*, curves of extreme amplitude at successive complete oscillations to a base of number of oscillations. A set of these is shown in Fig. 2 (page 567) for different starting amplitudes, and in Fig. 3 the same curves are shown superposed. These show that the damping at a given amplitude is greater when starting from rest at that amplitude than if the prism reached the particular amplitude by starting from a much larger one. After a few swings the damping is the same as if the motion had started from a much larger amplitude. In subsequent experiments it ap-

* Paper read before the Institution of Naval Architects, April 12, 1916.

† Trans. I.N.A., vol. xxiv., page 180.

peared only necessary to start from rest at an amplitude as large as possible. Each experiment was repeated.

To Obtain the Rate of Extinction.—The curves so obtained were differentiated by the method of differences—not graphically—the difference being measured on ordinates selected to give the best intersections. It appeared certain from the nature of the motion that some element of the resistance, as, for example, the effect of the ends of the prism, which in the present experiment has not been eliminated, at the velocities obtaining in the experiments, would vary as the first power of the velocity, while others—the effect of sharp corners and edges—would vary as the square of the velocity, some skin-friction elements of resistance would have a velocity



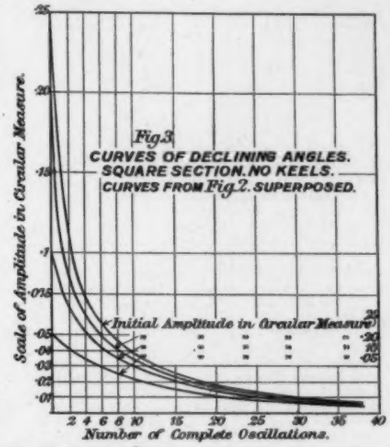


Fig.3.
CURVES OF DECLINING ANGLES.
SQUARE SECTION. NO KEELS.
CURVES FROM Fig.2. SUPERPOSED.
Initial Amplitude in Circular Measure
Scale of Amplitude in Circular Measure.
Number of Complete Oscillations.

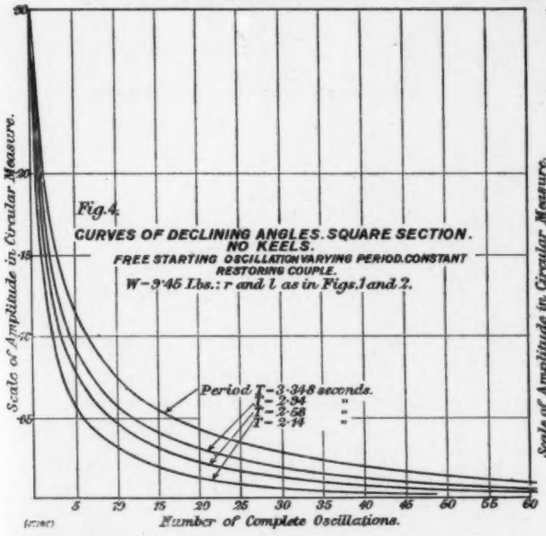
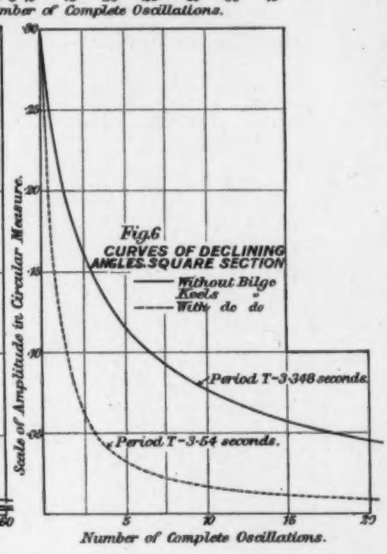


Fig.4.
CURVES OF DECLINING ANGLES. SQUARE SECTION.
NO KEELS.
FREE STARTING OSCILLATION VARYING PERIOD. CONSTANT
RESTORING COUPLE.
W=9·45 Lbs.: r and l as in Figs. 1 and 2.
Period T=3·348 seconds.
Scale of Amplitude in Circular Measure.
Number of Complete Oscillations.



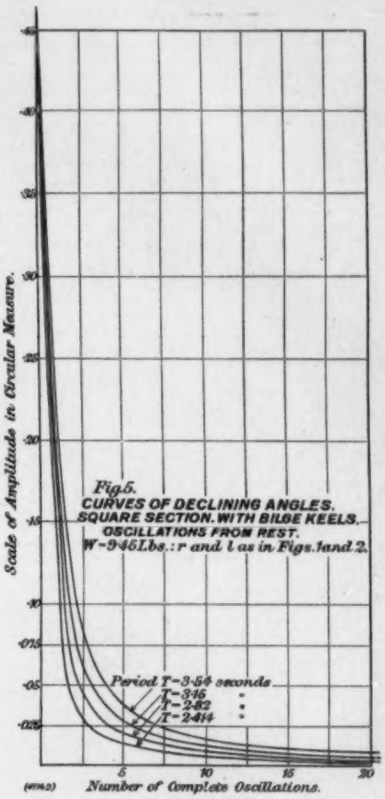


Fig.5.
CURVES OF DECLINING ANGLES.
SQUARE SECTION. WITH BILGE KEELS.
OSCILLATIONS FROM REST.
W=9·46 Lbs.: r and l as in Figs. 1 and 2.
Period T=3·54 seconds.
Scale of Amplitude in Circular Measure.
Number of Complete Oscillations.

index of something less than 2. It might be expected, then, that the extinction could be expressed fairly closely in the form :—

$$-\frac{d\,(H)}{d\,N} = a\,(H) + b\,(H)^2 *$$

Plotting $-\frac{d\,(H)}{d\,N}\,\frac{1}{(H)}$ to a base of (H) furnished at once values of a and b. It was found, particularly in the case of the block without bilge-keels, that the values of $-\frac{d\,(H)}{d\,N}\,\frac{1}{(H)}$ could be very well expressed by two straight lines yielding two sets of different values of a and b, one set holding for amplitudes below, the other for amplitudes above a certain value. The particular amplitude varied with the period of oscillation. With the bilge-keels one value for a and b expressed the results with sufficient accuracy, and the element of resistance varying as the first power of the speed was then quite a small proportion of the total resistance.

TABLE OF COEFFICIENTS IN $-\frac{d\,(H)}{d\,N} = a\,(H) + b\,(H)^2$ ((H) is expressed in degrees).

	Period T.	a	b	a	b	bT^2
		Small Amplitudes.		Large Amplitudes.		
No keels ..	3.348 secs.	0.031	0.007	0.0007	0.01664	*0.2098*
	2.94 ,,	0.04	0.0091	—	0.02386	*0.2062*
	2.58 ,,	0.042	0.0157	—	0.0305	*0.2036*
	2.14 ,,	0.054	0.0122	—	0.0436	*0.2000*
				For all Amplitudes.		
With keels..	3.54 ,,	—	—	0.017	0.0954	*1.196*
	3.15 ,,	—	—	0.026	0.1278	*1.266*
	2.82 ,,	—	—	0.053	0.1584	*1.260*
	2.414 ,,	—	—	0.087	0.1996	*1.166*

The method of experiment is not one to be commended to determine the law of variation of resistance with speed. The alteration in decrement due to a slight variation in the index of the speed law it would be almost impossible to determine by this method, so that it is impracticable to say whether the index of the resistance was, say, 1.8 or 2.0. Theoretical considerations tend to indicate that at any rate the vortex resistance (a considerable proportion of the total) must vary as the square of the speed, and the method will probably give a measure of resistance suitable for estimating the general effect of bilge-keels in quelling the rolling of a ship.

The results of the experiments as obtained directly, without any fairing or correlation between the different experiments, are shown in the following table in the form :—

$$-\frac{d\,(H)}{d\,N} = a\,(H) + b\,(H)^2$$

where (H) is the extreme amplitude of an oscillation in degrees, $d\,N$ is a complete oscillation to and fro.

The curves from which these figures are derived are shown in Figs. 4 and 5. A comparison between the damping of the block with and without bilge-keels is shown in Fig. 6.

If it be assumed that at any instant the moment of resistance varies as the square of the angular velocity or :—

$$R = k\left(\frac{d\,\theta}{d\,t}\right)^2,$$

it can be shown that, for a simple alteration in period, other conditions remaining the same, the product $b\,(H)^2\,T^2$ is a constant. The values of the product $b\,T^2$ for the larger amplitudes are shown in the table in italic figures, and it will be seen that this relation is fairly well verified by the experiments.

If the restoring couple due to gravity be the same per unit of angular displacement in the two cases, with and without bilge-keels, the products $b\,T^2$ will be proportional to the coefficient of resistance k. Except for the addition of the bilge-keels, the restoring couples were the same, so that, roughly speaking, the bilge-keels produce a resistance equal to five times that of the block without keels.

This result can be put in a more concrete form by assuming the whole of the resistance couple, as represented by the $b\,(H)^2$ term, to be replaced by a pressure always opposed to the motion acting at the radius of the centre of gravity of the keel area. In that case the pressure per square foot at a linear velocity of one foot per second works out at 21.26 lb. This result appears very large, but from the experiments on the Revenge, which had a very gently rounded section, Mr. R. E. Froude calculated that the pressure, if taken over the bilge-keels only, was 15 lb. to 16 lb. per square foot at 4 deg. angle of roll. (*Vide* Trans. I.N.A., vol. xxxvi., page 138.)

For comparing the damping effect of the square and other sections, it is convenient to assume a bilge-keel whose depth is equal to one-twentieth part of the side of the square, if situated at a mean radius equal to the distance of the corner from the axis, will produce the same result by suitably selecting the pressure. Such pressure in the case of the square section without bilge-keels amounts to 7 lb. per square foot.

9. *Effect of Presence of the Water upon the Virtua Inertia of the Oscillating System.*—The mode of experi-

* In analysing the results of the experiments no account has been taken of the air resistance of the supporting disc and the wires, or of the frictional resistance of the bottom pivot. It is extremely difficult to get accurately what, for want of a better phrase, may be called the "idle" friction. Damping experiments were carried out with the prism oscillating in air and the bottom pin dry. The damping was for all practical purposes constant, so that the equation giving the rate of extinction would be of the form :—

$$-\frac{d\,(H)}{d\,N} = A + B\,\theta + C\,\theta^2.$$

A was quite small, so that the results were analysed on the supposition that the damping due to pivot friction when oscillation takes place in water is much less than in air, and that the constant term might be neglected. It was noticed, however, that the introduction of a constant into the general expression for extinction did give a slightly better agreement with the experiment curve, particularly at the smaller amplitudes.

menting with a constant restoring force again lent itself to estimating the effect of the fluid upon the inertia of the system. By moving symmetrically weights through a known distance a known alteration of inertia could be made in the system. Since period could be measured with a considerable degree of accuracy by taking a number of swings, any such alteration in inertia would be followed by a corresponding alteration in period, and the inertia of the system could be determined from the formula :—

$$= \frac{i\,T_1^2}{T_2^1 - T_1^2};$$

where I is the inertia of the system, i is the alteration to the inertia by the movement of the weights, T_1 and T_2 are the periods corresponding to I and $(I + i)$. If the inertia were independent of period, and also of absolute angular velocity, it would be quite a simple matter to measure change in virtual inertia. Preliminary experiments were therefore made to determine whether such a relation held.

It was found that period decreased with increase in amplitude, due partly, and possibly chiefly, to the variation of the restoring couple according to the sine law instead of the linear law.

As soon as the amplitude approached angles at which $\sin\theta$ differs little from θ the period appeared constant for all amplitudes (without an accurate recording instrument available it was, of course, very difficult to measure any small change of period). With the keels fitted, and, starting from rest at an initial amplitude of 0.47 radians, the mean period for the first two swings to an amplitude of 0.12 radian was in one case 3.9 secs. against 3.55 secs. for small amplitudes. The figure 3.9 secs. is necessarily approximate owing to the method of measurement, but 3.55 is very close to the true period for small angles. If the liquid were perfect and the restoring couple varied as $\sin\theta$ at an angle of 0.47 radian, the period would be about 3.62 secs. This is contrary to experience in a ship where period usually diminishes with increase of amplitude, but there the restoring couple usually increases with amplitude more rapidly than the linear law, at any rate for moderate amplitudes, and period decreases.

To determine whether virtual moment of inertia varied with period was rather difficult by the usual method of differences, because if it varied sensibly it was necessary to use small differences, which rendered any estimates liable to considerable error. Using small differences to determine inertia led to very inconsistent results, from which the only lesson to be learnt was that inertia did not vary sensibly with period. By using larger differences, by which a degree of accuracy of about 1 per cent. on the difference could be obtained, the results were consistent, and showed definitely that there was no sensible variation in inertia for the limits of period selected for the experiment. The inertia of the system was measured both in air and in water, so that the difference gave the virtual increase due to the presence of the water. The difference, perhaps, can be most conveniently expressed as a mass acting at the radius of gyration of the square block :—

$$= \sqrt{\frac{d^2}{6}}$$

where d is the length of a side. Without the bilge-keels the apparent increase of mass was 28.5 per cent. of the displacement of the prism, while with bilge-keels it was as much as 72 per cent. Both these figures may appear rather large, but as far as the author can see there is no reason to discredit the results. The oscillation is, of course, partly vertical, but that element of the motion is so small, and the actual velocity is so extremely small, that it is not seen that this small translation motion can appreciably affect the result.

10. No suggestion has been made for applying the results of the resistance experiments to full-sized ships, but it appears that the law of dynamic similarity will apply here as in the case of skin friction. It is hoped at some future time to be able to give an account of the results of further experiments not yet analysed. The experiments were carried out in the Laboratory of the School of Naval Architecture in the University of Liverpool, chiefly at the expense of the University.

READERS' GUIDES.—The Public Library Committee of Norwich issues Readers' Guides as an assistance to those in search of information on special subjects in the Public Library. The latest deals with books for munition workers, aircraft, explosives, and child welfare. There are twelve previous sectional catalogues on sale at prices varying from a penny to eightpence, on application to Mr. G. A. Stephen, the City Librarian. The issues interesting to our readers are Natural Science (1984 vols.), Useful Arts (728 vols.), Philosophy and Bibliography (423 vols.).

STEAM-RAISING BY ELECTRICITY.—In some hydraulic power-stations there is, at certain seasons of the year, a surplus of energy available, which is commonly unavoidably run to waste. This has been the case at the Letten power-station of the Zurich Electric Power Company. At the same time it has been necessary to maintain for certain purposes a small steam plant. The company accordingly decided to utilise the surplus of power available for maintaining steam in a boiler for this plant. The boiler fitted has 1800 sq. ft. of heating surface, and with a maximum consumption of 84 to 86 kw. is able to supply 3800 lb. of steam per twenty-four hours, which suffices to run the feed-pumps and to keep hot the machines and the piping.

CATALOGUES.

Overhead Runways.—A catalogue which has reached us from the Brown Hoisting Machinery Company, of Cleveland, Ohio, U.S.A., gives some particulars of overhead runways operated by electric power or by hand. Several installations of these runways, handling all kinds of materials in factories, warehouses, engineering works, and industrial concerns, are illustrated.

Marine Signalling Lamps, &c.—We have received from the Bromell Patents Company, Limited, of 62, Robertson-street, Glasgow, a small catalogue giving prices and particulars of "Simplex" electric lamps for signalling at sea by means of the Morse code. It includes lamps supplied with current from the ships' lighting circuits, and portable lamps operated by batteries, the latter type being also useful as hand lamps for inspection purposes. Particulars are also given of an instrument which enables the speed and direction of rotation of the ships' engines to be seen at a glance. The instrument is operated electrically and comprises a pointer mounted in a circular case, which is fixed on the bridge, the pointer being deflected once to the left or right for every revolution of the engine in the ahead or astern directions respectively.

Rotary Planing-Machines.—We have received from the Newton Machine Tool Works, Inc., of Philadelphia, Pa., U.S.A., a catalogue relating to their rotary planing machines. These machines were originally designed for finishing the bases of iron and steel columns and rolled steel sections used in structural work, but are now quite generally employed for milling flat surfaces on engine and turbine bed-plates, split flywheels, and other castings. They are made either fixed or portable, and can be mounted on a circular base, so that the machine can be swivelled for angular cuts. The work is usually bolted on to a bed-plate and the cutter head is traversed along a slide, but in some of the smaller sizes the cutter head is stationary and the work is mounted on a travelling table. The cutters, which are of high-speed steel, are shaped similarly to lathe tools and are fixed near the periphery of a large disc by means of safety set-screws. Two of the cutters are made with broad faces, so that roughing and finishing cuts can be taken simultaneously or independently, as desired. Several installations of these machines are illustrated in the catalogue. Some examples of other products of the firm, including slotting-machines, cold saws, rail-ending machines, boring-machines, milling-machines, &c., are also illustrated.

Machine Tools.—A copy of the 1916 edition of their machine-tool catalogue has come to hand from Messrs. Charles Churchill and Co., Limited of 9 to 15, Leonard-street, Finsbury, E.C. This catalogue, which is extremely well printed and most profusely illustrated, contains about 400 pages, giving full particulars of various machine tools and accessories supplied by the firm, so that it is obviously impossible to enumerate all its contents. We may, however, indicate its scope by stating that, in glancing through it, we noticed milling-machines, gear-cutting machines, keyseaters and slotters, broaching-machines, radial and pillar drills, sensitive drills, boring-machines, shaping-machines, planers, lathes, automatic screw machines, pipe and bolt-screwing machines, cold saws, hack-sawing machines, filing-machines, &c., by many well-known American and other makers. A considerable part of the catalogue is devoted to grinding-machines, most of which were constructed by the Churchill Machine Tool Company, Limited, of Pendleton, and have been illustrated and described in the series of articles on this subject lately appearing in our columns. Several American machines, however, are also dealt with, and particulars of grinding wheels, dressing tools and other accessories, are also included. The catalogue also deals with portable electric drills, magnetic chucks, hand and power presses, bending-machines, riveting-machines, forging-machines, gas furnaces, forges, fans and blowers, and other requirements for engineers and manufacturers. The catalogue includes a complete general index to its contents and thus forms a very handy reference book for all users of machine tools. Its publication under the existing abnormal conditions is a particularly noteworthy achievement.

Motor-Starters and Controllers.—The General Electric Company, Limited, of 67, Queen Victoria-street, E.C., have recently issued a catalogue section giving particulars of "Witton" motor-starters, controllers, and regulators. Starters for continuous-current motors are first dealt with, prices being stated for starters ranging from ¼ to 100 horse-power in the open, semi-enclosed, enclosed-cover, and totally-enclosed patterns. For three-phase motors of the wound-rotor type plain starting resistances are listed. They are designed to allow the full-load current to pass on the first contact, so that the motor will start against the full load torque. These starters may be fitted with a catch to hold the starter in the "on" position against the tension of a spring, and, by pressing a knob, the arc flies back to the "off" position, and so avoids burning the contacts. For induction motors with squirrel-cage rotors, starters of the star-delta and auto-transformer types are listed. The former are used with motors taking a line current up to 50 amperes at 550 volts, when the starting torque does not exceed half the full-load torque, while for greater starting torques auto-transformer starters are recommended. As constructed by the General Electric Company, these starters comprise an auto-transformer and a change-over switch enclosed in a cast-iron case, and operated by an external handle. The tappings of the transformer, which may be oil-immersed if desired, are arranged to give 0.4, 0.6, 0.7, and 0.8 of the full-line voltage at the motor terminals. The catalogue also deals with liquid starters, complete starting-panels of the open and enclosed types, drum-type crane-controllers, controller-resistances, automatic motor-starters, multiple-switch starters, starters for single-phase motors, ironclad reversing-switches, shunt regulators, main-regulators, &c. Prices are stated for most of the apparatus dealt with, and we understand that the standard patterns can usually be delivered from stock.

Air-Pressure Regulator for Diesel Engines.—We have received from Messrs. Mirrlees, Bickerton and Day, Limited, of Hazel Grove, Stockport, a circular illustrating and describing an automatic device for regulating the pressure of the air used for injecting the fuel into Diesel engines in accordance with the load. The apparatus is made in two types, one operated electrically, and the other mechanically, but the pamphlet relates to the electrically-operated type only, which is suitable for use with electric generating sets. The device comprises a pressure gauge having two hands, one of which is operated in the ordinary way by a Bourdon tube in communication with the blast-pipe, and the other is moved by a solenoid carrying the load current, so that its position at all times corresponds to the blast pressure most suitable for the load carried. The hands are both fitted with electrical contacts, which complete the circuit of a solenoid controlling the throttle valve on the compressor inlet and thus close the valve when the hands coincide. If, while the engine is working, the load increases so that the blast pressure is lower than it should be, the pressure-controlled hand will lag behind the electrically-controlled hand and the compressor throttle valve will be fully open. The compressor will then be working at its fullest capacity, so that the pressure will soon rise and bring the pressure-controlled hand up into electrical contact with the other hand. When this happens the throttle valve will be closed and the delivery of air will cease as long as the hands remain in contact; but when they come apart, owing to the drop in pressure, the valve will open and more air will be delivered. In this way the air-pressure in the receiver will be automatically regulated in accordance with the load. It is claimed that better and smoother running results from the use of this device, and, among other advantages, it is mentioned that less attendance is required and a small saving in fuel is also effected, especially when engines have to run on variable loads. The parallel running of alternators is also said to be facilitated by the automatic regulation of the blast pressure.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

WE give below some data on a few colonial and foreign engineering projects, taken from the *Board of Trade Journal*. Fuller information on these projects can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

Canada.—The following particulars regarding the inception of new enterprises in Canada have been received at the office of the High Commissioner in London for the Dominion from the Minister of the Interior at Ottawa :—A large factory for the manufacture of oxygen and liquefied acetylene is to be erected in Winnipeg by a Montreal firm of chemists. The Manitoba Steel Foundries have commenced preliminary operations in connection with the erection of works at Selkirk, Manitoba. The plant and machinery will cost 75,000 dols. (about 15,400*l.*). The City Council of Moose Jaw is to construct a dam across the valley at Sandy Creek, Caron, Saskatchewan. When completed the reservoir will hold 200,000,000 gallons of water, thus ensuring a permanent water supply. Steel shipbuilding on a large scale is being inaugurated in Nova Scotia. Work on the erection of the shipyard near New Glasgow has already been begun.

Argentina.—The *Boletin Oficial*, Buenos Aires, publishes a Decree granting a concession to Señores Tomas T. Austin and Hermann Faesing for the utilisation of waters in the neighbourhood of Esquel, Territory of Chubut, for hydraulic power for industrial purposes. The concessionaires must present to the Argentine Irrigation Department, within the period of a year from the date of the concession, plans of the works to be carried out; the works must be concluded within three years from the date of the approval of the plans.

CANADIAN ROLLING-STOCK.—The first steel sleeping cars built in Canada have arrived at Moncton, New Brunswick. They are the first portion of a supply of cars ordered for the Canadian Government railways from Hamilton, Ontario. A Kingston firm has also secured an order for 30 locomotives for use upon the same systems. The engines are of an exceptionally large type.

"BETWEEN THE LINES."—A vivid record of work at the Front under this title by Mr. Boyd Cable was issued recently at 5*s.* by Messrs. Smith, Elder and Co., 15, Waterloo Place, London, and at once achieved a great success. As it clearly demonstrated the efficacy of guns, shell and other munitions, the happy idea was conceived of making an edition of 75,000 copies for free distribution, as far as it will go, among the managers and workers in munition factories and kindred establishments. The author and publishers have agreed to forego all profits, and thus it has been possible to arrange for this gratuitous issue. No one can read the book without realising the vital need for the maximum of effort of all engaged in providing the various weapons used by the troops, and we trust that the reading of the book by workers will result in a great stimulus towards greater diligence and less idleness in munition factories.